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User Centred Engineering in Automotive Design: A shift from technology-driven product development

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

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June, 2015

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Abstract

The global automotive manufacturing industry represents the pinnacle of technology-driven innovation, striving to produce marketable, high-tech products in a highly competitive industry. In recent times, challenging economic and market conditions have led some of these automotive manufacturers to question the time-honoured technology-driven approach to vehicle design, and to seek out new methods for vehicle design and development.

This has led to increasing recognition of the impact of rapidly changing consumer needs on the industry, and the realisation that future competitiveness and sales are dependent on producing vehicles that are designed for what the customer needs rather than what is most technologically advanced. Previous research highlights the potential added value of customer orientated design approaches, such as user centred design, to the pre-existing automotive manufacturing design process. The research presented in this thesis results as a counter to the research problem. That is, to the designer-centric focus of existing research into applied user centred design, which ignores the importance of the design contributions of technical staff, namely engineers, in automotive manufacturing organisations.

The objectives of this research are to assess how best to transition engineering-centric automotive firms towards customer-orientated design and development approaches, whilst identifying the main barriers and concerns facing such a shift. The research investigates the ability of a firm to empower individual engineers with user centred design tools traditionally used by designers, whilst understanding the company-wide needs to facilitate their implementation. Research data and findings were collected through a six-month placement with a German automotive manufacturer using an ongoing reflective journal, coupled with semi-structured interviews conducted with firm

staff following the completion of the placement. In order to evaluate the results and formulate usable outcomes, a thematic analysis was completed on the collected data.

The analysis of the research highlighted three key challenge areas that needed to be overcome by the automotive manufacturer in order to transition to a customer-orientated vehicle development process. Firstly, the existence of cultural and institutional inertia within the firm acts as a barrier to the adoption of new ideas, such as user centred design, due to the focus of existing firm behaviour and thinking on technology centred design. Secondly, the concentration of design process decision-making in the hands of management necessitates gaining buy-in from firm managers if user centred design is to be implemented within the existing vehicle design and development process. Finally, the research found that the institutionalised, technology driven requirements culture at the firm has resulted in engineers becoming disconnected from the customers for whom they are designing vehicles. Thus the final challenge posed to user centred design adoption is gaining buy-in with firm engineers, who are trained to focus on achieving technical targets handed down by management. In addition to identifying these key challenges, the research also identifies three core opportunities – a shift in company culture, communicating a UCD approach, and bringing UCD into the firm – to facilitate the implementation of user centred design approaches within the firm. These research findings provide a guide for firms looking to transition from a technology driven to a customer-orientated business model, focusing on the implementation of a user centred design approach.

The research concludes with the following recommendations for actions to be taken by the global automotive manufacturer involved in the research, for the global automotive manufacturing industry as a

whole, for future researchers looking to commercially implement user centred design, and for user centred design theory:

- The creation of a new role, "designeer", to act as a catalyst for the rollout and widespread implementation of UCD within the firm.
- The implementation of a user centred engineering canvas by the designeers to provide a new customer-orientated business model to company managers and encourage UCD-based decision-making.
- Increased exposure of low-level employees, such as engineers, to UCD through personas and storytelling. Facilitated by designeers through training in the firm's training centre and through persona and storytelling displays throughout the firm.

Keywords

Automotive Manufacturer

Business Model

Customer Centred

Designeering

Personas

Technology Driven

Technical Requirements

User Centred Design

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List of Abbreviations

BTO – Build to Order

BTS – Build to Stock

QUT – Queensland University of Technology

UCD – User Centred Design

List of Publications

Bryant, S & Wrigley, C 2014, 'The drive towards user-centred engineering in automotive design', In Bohemia, Erik, Rieple, Alison, Liedtka, Jeanne, & Cooper, Rachael (Eds.) *Proceedings of 19th DMI: Academic Design Management Conference, London*, UK, pp. 741-758.

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1.0 Introduction

1.1 Background

The global automotive industry represents the pinnacle of technology-driven innovation, striving to produce marketable, high-tech products in a highly competitive industry. This competition has led to the need for automotive firms to develop a customer-based approach to automotive manufacturing in order to differentiate themselves from the similarly technologically optimised crowd (Oliver Wyman Group, 2007). With this said, the customer-based approach that is becoming increasingly popular with automotive manufacturers places emphasis on sales & marketing of their products to potential consumers, in addition to the development of ongoing relationships with these prospective customers (Deloitte, 2008). However, in spite of this move towards a customer-orientated approach, automotive firms are still firmly entrenched in their reliance upon technology-driven innovation to design, develop and manufacture their products (Deloitte, 2009). Customer focus appears to act as little more than a way to sell the product to the customer.

In recent times, challenging economic and market conditions have led some of these automotive manufacturers to question the status quo and seek out new methods for vehicle design and subsequent sale to end-users. More specifically, the time-honoured technology-driven approach to vehicle design and manufacture is coming into question. The rising importance of rapidly changing consumer needs is making it difficult for automotive engineers to focus on the latest and greatest technology integration into their vehicles with little regard for the end-consumer (Accenture, 2010). This has led to the realisation by some automotive manufacturers that increasing future competitiveness and sales are dependent on producing vehicles that are designed for what the customer needs not just on what is the most technologically advanced. The integration of the customer into the

design process represents their next step forward in the highly competitive global automotive industry.

This move away from traditional, solely technology-driven innovation is being facilitated through the use of existing customer-orientated approaches. Examples of this include allowing pre-order customer-customisation of the vehicle, and a more user-centred sales and in-dealership experience. More specifically, it is a combination of the traditional technology push approach, and complimentary design pull approach, focusing on the meaning of the product to the customer (Dell'Era, Marchesi & Verganti, 2010). Such alternate approaches, exemplified by methods such as design-driven innovation, user centred design (UCD) and emotional design represent established methods for customer-focused design.

These methods are starting to be implemented by automotive firms seeking to gain a competitive advantage within their technology-driven industry. These methods emphasise the need for understanding the underlying needs of the customer, and how customers actually use the product; as opposed to how they say they do when interacting with customer relations teams. This understanding is often developed into 'personas', a UCD tool that provides representations of the overall needs, wants and values of customers within segments that are identified as important by manufacturers. These identified needs can then be implemented in vehicular design in order to provide maximum value to the customer segments targeted by the product/s.

Such a user centred approach to vehicular design has precedence. A user-experience design team at General Motors sought to gain a deeper understanding of how their drivers interacted with their in-car infotainment systems, in order to better tailor the design of these systems to the everyday General Motors vehicle user (Gellatly et al., 2010). In spite of the apparent move towards a user centred

approach to automotive project design and development, this project appears similar to many automotive design "success stories", such as the design of Ford's successful 2005 Mustang (Tischler, 2004). More specifically, these projects appear to be entirely design-centric, divorcing themselves from the reality of the multi-disciplinary nature of automotive vehicle development due to their lack of inclusion of non-design employees (Gellatly et al., 2010; Tischler, 2004; Satake et al., 2011; Patton, 2009).

1.2 Research problem

However, both designers and engineers are required to successfully realise the manufacture of a vehicle. That is, engineers are silently involved at some stage in these aforementioned projects given their pivotal role in the successful manufacture of fully functional vehicles. As such, UCD needs to be part of a multidisciplinary approach to product development that also takes into consideration a range of other requirements (e.g. technical, functional and business)(User Experience Professionals Association, 2014). This is due to the fact that designers and UCD are typically not operating in a vacuum, but rather as part of a larger business seeking to develop a new product (Wallach & Scholz, 2012). Such articles as mentioned in the previous sub-section highlight the current absence of the engineer from the design process, at least from the perspective of automotive designers.

This lack of interaction and integration between designers and engineers in development projects is often cited as due to the traditionally technology-driven nature of automotive engineers and manufacturing companies which are not accustomed to looking at design from a user centred perspective (Tütek & Ay, 2011). Such an argument, whilst seemingly logical at first glance, marginalises engineers through such a black and white perspective. It turns the design process into an "us versus them" debate between designers and engineers. This marginalisation of the segment of the automotive

development process responsible for the overall development and manufacturing of the product appears rather naïve. Although customer-orientated approaches are typically developed within non-technical departments (i.e. by designers), such an approach needs to be adopted by the technical (engineering) staff in order for it to be successfully applied in the physical product. Furthermore, past UCD, persona driven projects, such as that completed by Microsoft (Pruitt & Grudin, 2003) belie the notion that technical staff are divorced from the UCD process, with the inclusion of software engineers from the commencement of their persona project.

1.3 Objectives of the research

As an engineer interacting with engineering staff of a global automotive manufacturing firm (henceforth referred to as 'the firm') via action research, the researcher is attempting to analyse the challenges and opportunities facing the transition of this engineering centric firm towards the acceptance and implementation of user centred design. In contrast to typical UCD and persona tool studies which assess the implementation of these tools from the perspective of a designer (Cooper, 2004; Bucolo & Matthews, 2010; Dell'Era, Marchesi & Verganti, 2010; Gellatly et al., 2010), the aim of this research is not to understand how better to enable designers within the automotive industry to effectively implement customer-centred design. Rather, it is to assess the interaction of designers and engineers in the development of a product and how best to empower engineers with tools traditionally used by designers. This understanding will be developed in order to allow for a user centred approach throughout the entire automotive development cycle. The objectives of the action research entail:

1. To understand the key barriers and concerns pertaining to the implementation of UCD through design tools such as personas within engineering departments.

2. To assess the most appropriate strategy for successful implementation of UCD within the engineering development process of an automotive manufacturing firm.

Due to the focus of the case-study firm on a trial project centred on the use of persona design, the research uses personas to represent UCD as a whole when discussing the potential transition towards firm-wide UCD implementation with firm employees. These objectives will help to guide the research towards answering the following research questions

1.4 Research question

What are the key challenges and opportunities in seeking to successfully integrate user centred design through the adoption and implementation of personas in an automotive manufacturing company culture?

1.4.1 Sub research questions

What stereotypes exist that may act as barriers towards the implementation of user centred design by engineers in the company?

What benefits are provided to the technical design process by the adoption by engineers of user centred design within complex automotive manufacturing projects?

1.5 Significance of the research

The research outlined in the following thesis seeks to add to the existing body of knowledge in UCD and the automotive manufacturing industry through an improved understanding of the interaction between design methodologies and engineers in the product development process. Whilst there is a small amount of research into the application of a user centred design approach in the automotive industry, no studies into the adoption and use of such design tools outside of design departments currently exist. Given the pivotal role played by technical departments stocked with engineers

in the vehicle design and development process, lack of research into the attitudes and amiability of engineers towards the adoption of design tools represents a limited understanding of the potential for wider appreciation and adoption of designer-led approaches within the automotive industry. Moreover, understanding the challenges, opportunities and limitations seen by automotive engineers in UCD represents an opportunity for more effective communication between engineers and designers and the potential for minimising future interdisciplinary disputes as raised by Tütek & Ay (2011).

From the perspective of the case firm, an increased understanding of the potential for UCD implementation poses a significant opportunity to the bottom line. More specifically, by enabling their design and development processes to produce vehicles that better meet the needs and desires of their customers, the firm has the potential to gain a competitive advantage in the competitive global automotive industry (Oliver Wyman Group, 2007).

Finally, the research contributes to the existing body of knowledge regarding the implementation of design approaches such as UCD in technology driven industries such as the automotive manufacturing industry. This is achieved through a detailed identification of issues affecting the attitudes and barriers of technical staff (i.e. engineers) towards these approaches, and the development of a UCD framework to assist engineers in incorporating design thinking into their traditionally technical orientated work. Furthermore, this research will benefit the academic engineering and design communities, by providing insight into how the use of design-based concepts can be successfully adopted by the engineering community at a more general industrial level for positive commercial impact.

1.6 Structure of the thesis

The following body of the thesis contains 9 sections. Sections 2 through 5 examine the existing literature surrounding the automotive industry,

the vehicle design and development process, and the theoretical framework underpinning user centred design. Section 6 outlines the case study firm and its relation to the research, whilst Section 7 describes the methodology used to conduct the research. Finally, Sections 8 to 10 provide the research results, discussion, and subsequent implications and conclusions to the work.

Section 2 investigates the automotive industry, and the events that have transpired to provide the impulse for action in the case firm, as described in Section 6. The historical development of the industry is outlined, setting the stage for the movement of firms towards new business models in an attempt to gain a competitive advantage. These business models are explored in detail, with specific attention given to user focused business models that have been trialled in individual firms' projects.

Section 3 discusses the traditional design and development approach used by automotive manufactures to produce vehicles. The step-by-step methodology is deconstructed in this section, in addition to the historical roots of the contemporary approach. Finally, the role of engineers and designers in the vehicle development process and their conflicting approaches is explored.

Section 4 details the theory surrounding user centred design. In addition to the theoretical background, methodology and tools used in UCD, this section also examines examples of its application in industry. Specific focus is paid to the use of UCD within the automotive industry.

Section 5 provides a summary of the literature reviewed in Section 2 to 4. Further to this summary, the gaps in the available literature are also identified, and discussed with respective to their opportunity to be addressed by the research.

Section 6 describes the case study firm, including its history, position in the market, and existing attempts to innovate its business model. Details concerning current firm research into UCD and its relation to the researcher will also be described, providing a foundation for the work presented in this thesis.

Section 7 documents the methodology used in conducting the research. The methods of data collection, namely qualitative interviews and a reflective journal, are described, following which the method used to analyse the data is outlined. Strengths and weaknesses pertaining to the data collection approach (action research) and the analysis method (thematic analysis) are then discussed. Finally, the ethical considerations pertaining to the research are addressed.

Section 8 presents the research findings, broken down into three key themes. These themes refer to the challenges facing the implementation of UCD within the existing vehicle design and development process at the firm. The first theme focused on the inertia resulting from institutionalised culture and behaviour that needed to be overcome within the firm when implementing new methods and approaches. Secondly, the concentration of decision-making power with departmental managers was identified as a significant contributor to the ongoing technology driven orientation of company objectives. Finally, it was found that engineers within the firm were disconnected from and had little understanding of the firm's customers due to their institutionalised need to focus solely on technical vehicle requirements.

Section 9 investigates the ramifications of the research results for both the case study firm and for user centred design theory.

Section 10 seeks to define the findings and their potential implications, both commercially and theoretically, before outlining the potential for

future work. The section also aims to bring the thesis to its conclusion through a reflection upon the research and concluding comments from the researcher.

The section above has provided an introduction to the thesis in addition to the aim and objectives of the research, including its significance and research questions. The following section reviews literature pertaining to the global automotive industry. Thereafter, literature concerning vehicle design and development and user centred design will be examined.

2.0 Automotive Industry

2.1 Introduction

In an industry worth more than €500 billion annually, producing more than 80 million vehicles worldwide each year and consisting of over 50 major manufacturers worldwide, the automotive industry represents a lucrative but highly competitive manufacturing industry (ACEA, 2012; Deloitte, 2009a). This global industry can be divided into five main regions, representing total world passenger car production (ACEA, 2012):

- European Union (EU) – 26.2%
- North America – 9.4%
- Japan and South Korea – 18.9%
- Brazil, Russia, India and China (BRIC) – 36.4%
- Rest of World (RoW) – 9.1%

Such geographical division represents both the production hubs and overarching target markets of the automotive industry. Further dividing the industry is the delineation of vehicles into three main segments based on the types of vehicles produced for any given vehicle class (McKinsey, 2013):

- Premium segment (~10%); luxury vehicles with the highest margins
- Value segment (~70%); mid-priced vehicles
- Entry segment (~20%); least expensive vehicles

This diversity of target markets and products represents a significant challenge to automotive manufacturers. With 10 automotive manufacturers meeting over 75% of global vehicle production in these markets, continued innovation is necessary for firms to maintain and develop their market share within the future automotive industry (Deloitte, 2009a). Such innovation traces its roots back to the dawn of the automobile and competition within a burgeoning industry.

2.2 The drive for innovation

The modern automobile has its origins in the late 1700s with the technological pursuit of self-propelled road vehicles (Fink, 1990). The pursuit focused on innovation within steam-, electric- and internal combustion-based motor technology. This innovation, driven by technological advances, culminated in the development of the precursor to the modern petrol-driven passenger vehicle by Karl Benz and Gottlieb Daimler in 1885 (Clarke, 2003). However, the foundling automotive industry was originally a niche market for custom built vehicles for the rich and wealthy (University of Colorado Boulder, 2014). It took further development in the areas of manufacturing standardisation and the implementation of assembly lines for the automobile to come to dominate the passenger transportation sector (Clarke, 2003).

Representing the beginnings of a modal shift in transportation and engineering practices in the early 1900s, technological advancements in vehicle manufacturing and assembly processes allowed for the birth of mass production of affordable automobiles (Fink, 1990). The Model T Ford vehicle, developed in the U.S. by Henry Ford, is widely acclaimed as the first mass-produced vehicle. Its conception in 1908, and the development of the moving assembling line in 1913, was the start of a technology-driven innovation battle in the automotive industry. The development of this standardised manufacturing technology allowed for the production of large numbers of vehicles at lower prices than the previous generations of handcrafted vehicles, and resulted in a significant reduction in the number of competitors in the industry (Fink, 1990).

This global reduction in vehicle manufacturers was none more apparent than in the U.S., decreasing from approximately 2000 firms in the early 1900s down to 44 by 1929 and 11 in 1976 (University of Colorado Boulder, 2014). The concentration of the automotive industry

down to a small number of firms resulted from the centralisation of large manufacturing facilities, which put many smaller companies out of business (University of Colorado Boulder, 2014). Despite the reduced number of automotive manufacturers in the industry by the late 1920s, the industry was seen to remain stiffly competitive and firmly focused on the technology and standardised engineering processes required to construct a vehicle (Klepper, 2001).

The great depression of the 1930s and the advent of the Second World War resulted in a significant downturn in production in the industry through to 1946 (Dreyer, 2009). However, continued innovation by automotive manufacturers was driven by technological advancements in increasingly automated manufacturing processes, part interchangability and the widespread adoption of the moving assembly line (Clarke, 2003). This further entrenchment of standardisation and mass production built upon the precepts of Henry Ford, and was a direct result of WWII. The drive for technical innovation in automotive manufacturing resulted from the need for countries on both sides of the war to keep up with the growing demands of their respective war machines (Clarke, 2003). High levels of idle production capacity and demand for personal transportation in the aftermath of WWII, combined with the further refinement of production processes during the war, set the stage for the modern technology-driven automotive manufacturing industry (University of Colorado Boulder, 2014).

From catalytic converters to airbags and antilock breaking systems, post-WWII automotive manufacturing saw a continued dependence on technological innovation in its products (National Academy of Engineering, 2014). Such technological dependence was a result of both external forces and traditional industry practices. External forces such as environmental lobbying and the oil embargoes of the 1970s forced manufacturers to engineer more fuel-efficient vehicles (Dreyer,

2009), whilst the internal push for profits via increased efficiency in the vehicle development process (U.S. Library of Congress, 2014) further emphasised the technical centricity of the industry at a global level.

The increasingly globalised nature of the industry in recent years has led to a rise in fierce competition amongst manufacturers, with traditional manufacturers starting to feel the strain (U.S. Library of Congress, 2014). Sluggish sales in traditional sales regions (namely Europe and Northern America; see Figure 1) due to the effects of the global financial crisis have resulted in firms branching out in recent years into growth regions such as Asia and South America. However, such expansion into new territory has required firms to rethink stereotypical engineering approaches that have defined their traditional technical business models in an attempt to gain an edge on the equally technologically advanced competition (Accenture, 2010).

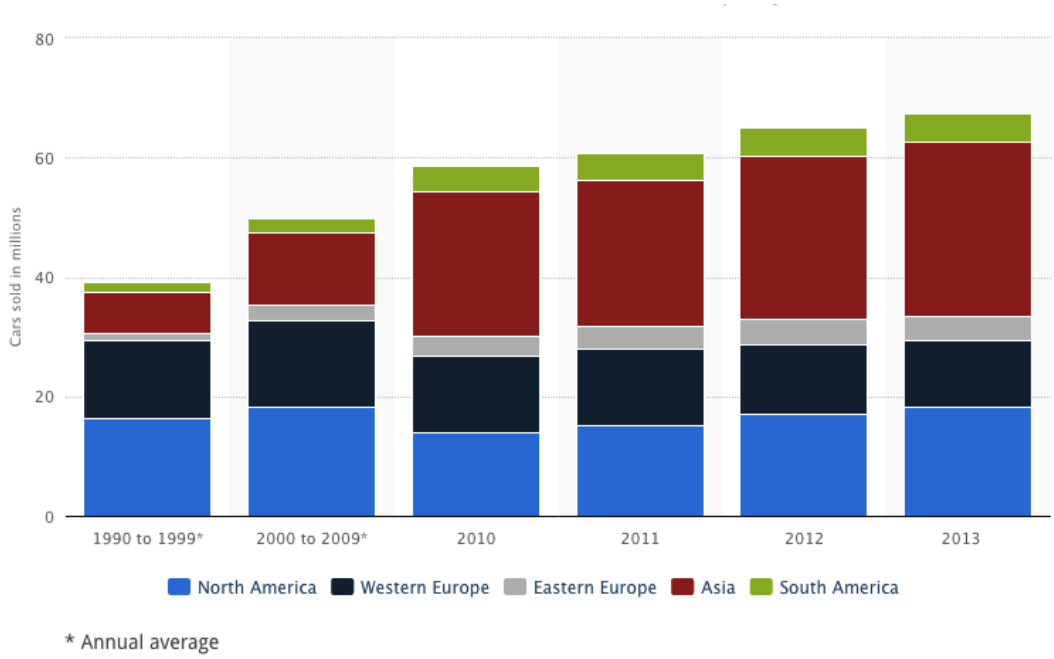


Figure 1 - Number of cars sold worldwide from 1990 to 2013, by region (in million units) (Stastista, 2014)

2.3 Automotive business models

A combination of a slow recovery from the global economic crisis, and the encroachment of new manufacturers in China and India upon existing market shares, automotive manufacturers have been increasingly turning to new business models to drive growth and capitalise on customer needs. By the term 'business model', the researcher is referring to "the rationale of how an organization creates, delivers, and captures value" (Osterwalder & Pigneur, 2010).

2.3.1 Business model breakdown

In seeking to create, deliver and capture value, businesses are ultimately striving to undertake innovative activities to gain a competitive advantage in the market (Zott & Amit, 2010). Osterwalder and Pigneur (2010) suggest that such activities can be described through a framework of 9 key building blocks known as the 'business model canvas', as shown in Figure 2. These building blocks include:

- Customer segments; the customers served by the organisation
- Value propositions; the product or service provided to customers to meet their needs or solve their problems
- Channels; how the value propositions are delivered to the customer
- Customer relationships; what relationships are formed and maintained between the firm and their customer segments
- Revenue streams; what revenues are generated from the value proposition
- Key resources; what assets are required to provide the value proposition
- Key activities; what activities must be performed to produce the value proposition
- Key partnerships; who needs to be involved (externally and internally) in the process
- Cost structure; what costs are involved in the process

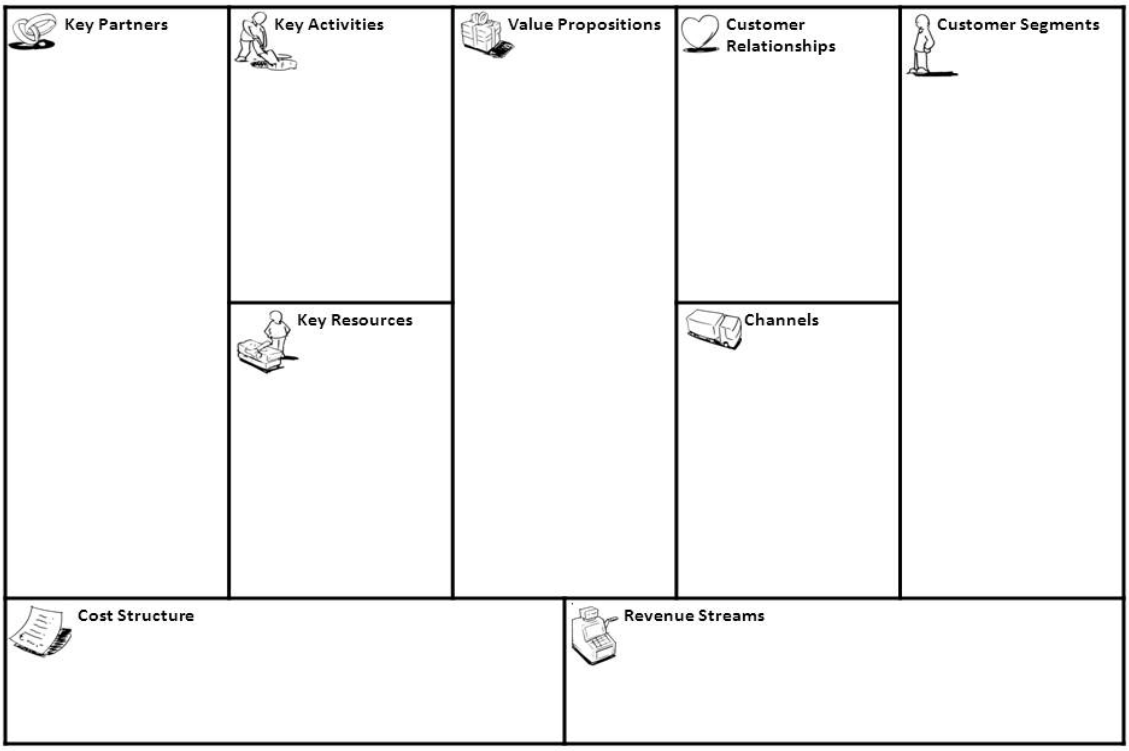


Figure 2 - Business model canvas (under creative commons licence from BusinessModelGeneration.com)

The business model canvas is used by automotive firms to better elaborate upon new visions and visualise the process for relevant project stakeholders, as show by Wijnen (2013) in the BMW 'Drive Now' project.

Through these building blocks the business model canvas acts "like a blueprint for strategy to be implemented through organizational structures, processes and systems" (Osterwalder & Pigneur, 2010). It provides a shared language for members of a firm to challenge existing business models and activities and to develop effective alternatives. This framework for developing new business models has been adopted by companies in a wide variety of industries and is becoming a standard method for innovating new business practices (Leonard, 2014).

2.3.2 Application of business models

In the context of the automotive manufacturing industry, the concept of a business model can be thought of as the way in which

manufacturers develop a means of transportation i.e. a vehicle, and deliver the potential for personal mobility to customers via this medium whilst being paid for the product. The origins of this contemporary automotive business model stem from the technical innovations of mass production and standardisation within the industry (Wells, 2013).

The optimisation of the vehicle manufacturing process led to the adoption of a model known as 'Build to Stock' (BTS)(Parry & Roehrich, 2013). This model seeks to leverage the high production capacity of manufacturers to distribute high volumes of vehicles to independent franchised dealerships i.e. vehicles are stocked with a middleman prior to sale to the end customer (Wells, 2013). High volumes of production combined with cost reduction through production efficiencies gained by economies of scale have allowed manufacturers to monetise their business model with little concern for the fate of the vehicle after the point of sale (Wells, 2013). However, this model is predicated on two key assumptions (Wells, 2013):

- There will be a continued increase in vehicle sales to drive profit growth.
- Customers are willing to purchase standardised "off the shelf" products.

With stagnating sales in traditional markets (Stastista, 2014) and the need to turn towards a market with different customer requirements i.e. Asia (Accenture, 2010), manufacturers have started searching for alternative business models in an attempt to remain competitive.

In this quest for innovative business models, many firms have focused on adapting their technical capabilities. Namely, pushing for "build to order" (BTO) process rather than the current BTS approach in order to reduce overall value-chain costs and to increase efficiency (Parry & Roehrich, 2013). BTO is "a demand-driven production approach where a product is scheduled and built in response to a confirmed order

received for it from a final customer" (Parry & Roehrich, 2013). This approach reduces the amount of capital locked into stock waiting to be sold, and attempts to improve the ability for manufacturers to supply customers with vehicles they desire rather than a standard model (Parry & Graves, 2008).

At first glance such a shift from a BTS to BTO business model appears sound. Reducing the level of risk in having large volumes of vehicles in stock whilst providing customers with the opportunity to customise their vehicle to their liking. However, such an approach, leading to over 550,000 permutations of a single vehicle model (Gunasekaran & Ngai, 2005), is at the heart of the pre-existing problem. By focusing on technology driven supply chain solutions and shifting vehicle selection responsibility to the customer, many manufacturers are failing to address the underlying problem with their business models. That is their dependence on technology driven innovation, and the lack of importance placed on taking a customer-orientated approach to vehicle development (Oliver Wyman Group, 2007).

Many manufacturers know too little about such customer requirements, with many integrated components and features not used by customers due to their complexity and lack of explanation. This is further highlighted by the fact that only 1 in 6 "optional extras" offered for purchase with a stock car are ever actually purchased by a given customer (Oliver Wyman Group, 2007). Such overwhelming complexity, as highlighted by the rise in 'optional extras' components in a BMW 7 series from 14 in 1986 to 92 in 2006 (and the 550,000 possible permutations of vehicles proposed by the BTO model), is further complicated by the wide range of target markets in the global automotive industry (Oliver Wyman Group, 2007). Each of these markets contains their own individual customer requirements that need to be addressed by manufacturer product offerings.

Manufacturers must suitably address such needs in order to maintain their competitiveness (Tischler, 2004). This raises the importance for manufacturers to overcome their existing technically centred stereotyped production approach and gain a better understanding of their customers. Such a customer-centred focus is vital in order to develop suitable vehicle models (and components) that are most likely to succeed i.e. be purchased. This will likely become a necessity in the automotive development process for companies wishing to maintain a competitive advantage in the future (Oliver Wyman Group, 2007).

2.4 Seizing opportunities

Despite the apparent technology driven nature of automotive manufacturing, the concept of focusing on the customer is not entirely new to the industry. Connecting with the customer has been a traditional part of automotive sales and marketing (McKinsey, 2014). As highlighted in Ali, Gafar and Akbar (2013), companies have typically focused on identifying the influence of their brand on the customer and identifying effective promotional strategies in order to boost sales of their vehicle models. However, this traditional customer-centred approach focuses on selling the same technology driven vehicle innovations via a change in branding image and marketing channels (IBM, 2012).

Outside of the realms of sales and marketing, customer-centrism has been the domain of the automotive designer. Often associated with the look and feel of the car, as in Satake et al. (2011) and Tischler (2004), a more recent shift in industry sentiment towards more customer-centred methodologies (Oliver Wyman Group, 2007) has seen a rise in the experimental use of design tools to aid in focusing overall vehicle design on the end user i.e. the customer. From User Experience (UX) contextualisation of social driving experiences at BMW (Knobel et al., 2012) and overall vehicle component design at

suppliers (Tscheligi, 2012), to the use of Human-Machine Interface (HMI) processes by General Motors to better understand the use of the vehicle by the end users (Gellatly et al., 2010), many large manufacturers have started to adopt design tools in order to better incorporate the needs of the customer into their final product.

This is none more evident than in the case of the Ford Verve concept, later to become the seventh generation Ford Fiesta. The development of a fictional character based on real-world statistical customer research by Ford designers served as the focal point for all members of the design studio (Patton, 2009). The centralisation of the customer in the design process through the personification of target customer needs also tied-in with Ford's attempts to promote the Fiesta as a global model palatable in all major automotive markets (Patton, 2009).

However, whilst the aforementioned approaches represent a key step in bringing the user into the automotive manufacturers' design process, it highlights a key absence by the focus on the automotive designer. That is, the absence of a central figure within the vehicle development and manufacturing process (see Section 3.0), namely the automotive engineer. The visible absence of the engineer stereotyped as to only being concerned with technical requirements, in the recent shift towards discussions of customer-centred vehicle development (Knobel et al., 2012; Tscheligi, 2012; Gellatly et al., 2010; Patton, 2009) represents a distinct opportunity. This opportunity is to bring the customer into focus of not only the sales and marketing teams or of the designers, but to the heart of the technology driven automotive manufacturing process, to the engineers.

2.5 Summary

This section of the report examined the existing literature on the automotive industry and the push of individual companies to gain competitive advantage through the development of new business

models. This push was addressed in the context of the opportunity provided to user centred approaches such as UCD. Furthermore, the challenges facing such approaches within the automotive industry were also documented.

The literature indicated that the automotive industry has historically developed and grown through technological innovations. Whilst this technology driven development has been successful for manufacturers in the past, recent industry development suggests that firms are seeking to innovate their business models, not just technologically, in order to gain an advantage in a very competitive industry. Research suggests that this has resulted in companies investigating opportunities provided by more customer-centred approaches to the traditionally technology-driven business models. However, existing literature in the adoption of user centred approaches in the automotive industry is currently limited to its use by designers and their projects. Given the key role played by automotive engineers within the vehicle development process, this suggests a significant gap in the theoretical and practical understanding of the challenges and opportunities for adapting a user centred design approach to existing automotive engineer practices.

The research deconstructed in this section relates to the sub-research question: *What stereotypes exist that may act as barriers towards the use of personas and user centred design by engineers in the company?* Given this movement by firms towards more user orientated business models, a shift in the fundamental vehicle design and development process of automotive engineers and manufacturers appears to be required in order to successfully facilitate a complete transition.

3.0 Vehicle Design and the Development Process

3.1 Introduction

The design of a new vehicle, from the initial perceived customer need through to its finalisation for manufacturing, continues to represent a major investment for automotive manufacturers. With research and development costs reaching up to $6 billion U.S. (Viswanathan, 2013) and ultimately determining 70% to 90% of total project costs (Bhimani & Mulder, 2001; Shehab & Abdalla, 2001; Jaikumar, 1986; Soderberg, 1989), the design process poses a significant financial risk. Similarly, manufacturers typically require between 3.5-5 years of time to bring a complete vehicle to market (Sorensen, 2006). This represents a significant investment of company time, in the form of both employee working hours and the lost opportunities of alternative projects, with success ultimately dependent on the design and development of a product that sells (Ramsey, 2013).

3.2 Historical development and practice

The importance of design on vehicle sales and subsequently upon the competitiveness of automotive manufacturers, whilst not a new phenomena (James, 1928; Beecroft, 1927), shares an intertwined historical development with the automotive manufacturing industry as a whole. This development originated with the design of the original automobiles as motorised versions of bicycles and horseless carriages (Clarke, 2003). However, as automotive engineering and manufacturing techniques were driven by technological advances to evolve, so too was vehicle design. This was made apparent by the shift towards designs that easily accommodated the process of manufacturing and subsequent maintenance (Fink, 1990), but still failed to include such elements as an enclosed cabin to protect the user from the elements or headlights to facilitate safe nocturnal travel (Moore, 1998). Further evidence of such technology-driven influence

on initial automotive design was famously uttered in 1909 by the father of modern automotive production, Henry Ford (1922, 71):
"*Any customer can have a car painted any colour that he wants so long as it is black*".

This technology-centric mindset towards vehicle design epitomised the revolutionary onset of mass production capabilities within the industry. In the years leading up to World War II, this mentality resulted in 'design for production', spearheaded by Henry Ford (Barnard, 2002). Whilst designing early motor vehicles for ease of production initially produced user-friendly designs (such as the Model T Ford), this was predominantly a result of the drive towards simplifying vehicle component requirements in order to simplify the manufacturing process and its costs (Barnard, 2002). Such designs resulted in cheap vehicles that were affordable for the general public, and served to open up automotive ownership to the wider public. This widening of the customer market served to bring customer requirements more firmly into the automotive design picture, as manufacturers had to appeal to a larger variety of clientele.

Following World War II, this large customer market resulted in the engineering of design features for user comfort, usability and safety. Such features had lagged behind the development of the technical capabilities of vehicles, and manufacturers sought to redress this absence (Barnard, 2002). Furthermore, during this post-war period, the use of aesthetic styling by designers rose to prominence in the design process, using the visual appearance of the vehicle as a means to convey a message to the customer and attract them to the product (Jaafarnia & Bass, 2011). In contrast, attempts by engineers to improve on vehicle performance (e.g. through improved vehicle aerodynamics to reduce fuel consumption) in the 1950s and 1960s were a commercial failure due visual designs that proved unattractive to potential customers (Barnard, 2002).

The 1970s reflect the onset of the modern design process that continues to this day. This modern era resulted from a significant shift in responsibility for the design of the vehicle, with designers taking responsibility for ensuring designs connected emotionally with the customer, in addition to providing suitable functionality (Jaafarnia & Bass, 2011). In contrast, engineering fixed its attention to the manufacturing process, driving technological innovation towards improved efficiency and reduced production costs (Barnard, 2002).

Recent decades have seen further movement towards a better understanding of customer needs. The rise of online feedback mediums and rapid digital prototyping have allowed designers to better interact with customers to gauge their true needs (Mattison, 2006). However, whilst the designers within the vehicle development process have progressed towards a user centred mentality, the final design is still restricted by the engineering requirements and limitations, with the final product design remaining the responsibility of automotive engineers (Sorensen, 2006; Khadani, 2005; Design Museum, 2013). This suggests, that while there has been significant progress towards the user centred business model outlined in Section 2.0, vehicle design and development is currently restricted by traditional technology-driven values.

3.3 The process

The design and development process within the automotive manufacturing industry can be defined as the "creative response to meeting an identified need" (Armstrong, 2008). That is, it is the development of a vehicle design that meets the presupposed needs of the target customers. This process has its roots in engineering design, which traditionally seeks to develop product solutions in answer to pre-existing problems or perceived human needs (Khandani, 2005). With such technical roots, it is perhaps unsurprising that vehicle development has a rather clear, if not entirely technical design

process (differing between manufacturers), as generalised in Figure 3. However, the design and development of a vehicle requires a multi-disciplinary team to succeed, and includes members from: marketing, research and development, design, system engineering, and manufacturing (Design Museum, 2013). Each part of the team contributes their disciplinary strengths at different stages of the process, as detailed below.

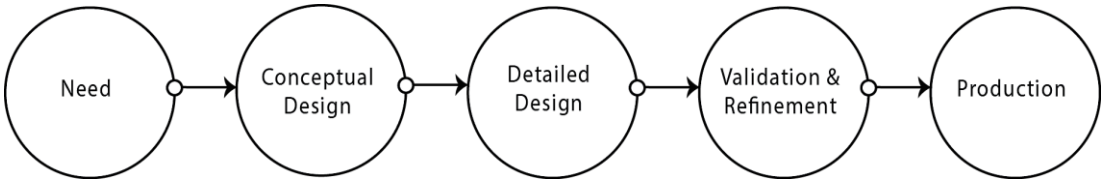


Figure 3 - Generalised automotive development process (adapted from Sorensen, 2006; Khadani, 2005; Armstrong, 2008; Leaney & Marshal, 2002)

3.3.1 Definition of customer need

Arguably the most important step in the development process, the definition of the customer needs to be met by the vehicle represents the first step. This step is typically a result of feedback from the marketing department concerning market research and user evaluations that suggests the need for a new vehicle (Design Museum, 2013). Following assent from management, a 'brief' is compiled detailing the definition of long-range objectives of the project (Strong, 2014; Armstrong, 2008). These objectives outline the target market, price range, performance parameters and target customers (Clark, Chew & Fujimoto, 1987), and are obtained through competitor product surveys, customer interviews, questionnaires and surveys, and subsequent research by the marketing department before finalisation by management (Khadani, 2005).

3.3.2 Conceptual design

Following the establishment of the customer needs, management hands the project over to the designers to develop a number of possible design concepts based on the defined project objectives

(Design Museum, 2013; Armstrong, 2008). These design concepts are typically generated via brainstorming, sketching and rendering (Strong, 2014; Khadani, 2005) and culminate in a number of potential vehicle layouts i.e. the potential total vehicle structure (Sorensen, 2006). The best concepts are then selected for modelling using 3D computer aided drawing (CAD) software with in-built product restrictions based on initial engineering feasibility requirements (Design Museum, 2013). Following the 3D modelling of the best design concepts, the designs are then machined into clay to provide life-size models for subsequent user assessment and feedback (Strong, 2014). This feedback is gathered via the marketing department, and is used by the designers to pare down the conceptual designs (Design Museum, 2013).

3.3.3 Detailed design

In progressing towards a manufacturable vehicle design, the concept designs generated by the designers must be detailed and tested so as to provide specifications for all individual components that must be produced to form the final vehicle (Sorensen, 2006). At this stage of the development process, the conceptual designs are passed on, in the form of technical specifications, from the designers to the engineers for analysis. The engineers computer simulate and analyse the design solutions, looking at functionality, ergonomics, strength, manufacturability, safety, regulatory compliance and cost, and comparing the results of these analyses with the project brief (i.e. initial specifications received from management)(Khadani, 2005; Design Museum, 2013). This process culminates with a single detailed design that has been computationally engineered to maximise performance and minimise overall costs (Strong, 2014).

3.3.4 Validation and refinement of design

In finalising the detailed design of the vehicle in preparation for manufacture, the engineers must first validate their computational analyses and simulations through the application of real-world trials. That is, prior to the design being approved for manufacture, the detailed design must be prototyped and tested (Sorensen, 2006). This process consists of the construction, testing and refinement (redesign) of individual components, and subsequently of a fully functional prototype. The finished prototype is then used to test the operational characteristics of the vehicle under a variety of real-world road conditions (Khadani, 2005). The usability and safety of the final product in addition to its environmental impact and performance in comparison to the project brief are examined (Design Museum, 2013). Upon satisfactory completion of testing and project brief requirement comparison, the design is finalised and ready for manufacture.

3.3.5 Production of finalised design

Following the finalisation of the design by engineers, the vehicle design is then given over to manufacturing for production. This requires the communication of the details of the finalised design to the manufacturing department, in addition to all pertinent contractors and component suppliers (Design Museum, 2013; Strong, 2014). This handing over of the design signifies the end of modifications to the design. However, engineers and management are still involved in the organisation of the required resources (materials and equipment) for production, and the establishment of quality management procedures to ensure the end product meets the envisioned expectations set out within the original project brief (Armstrong, 2008).

3.4 Design, engineering and developmental friction

From examining the typical design and development process in Section 3.3, it is evident that both designers and engineering are integral in the successful design and manufacture of a vehicle.

However, examination of the history of the design and development process in Section 3.2 suggests that these two groups tend to operate in relative isolation in the process. This becomes evident when looking at the involvement of each group within the process, as shown in Figure 4. In the developmental process, interaction between designers and engineers is predominantly limited to the hand-over of the designers' conceptual design to the engineers for quantitative analysis and testing (Sorensen, 2006). Such an institutional lack of integration between designers and engineers has been cited as cause for conflict and friction between the two parties, impacting upon the development process (Tütek & Ay, 2011).

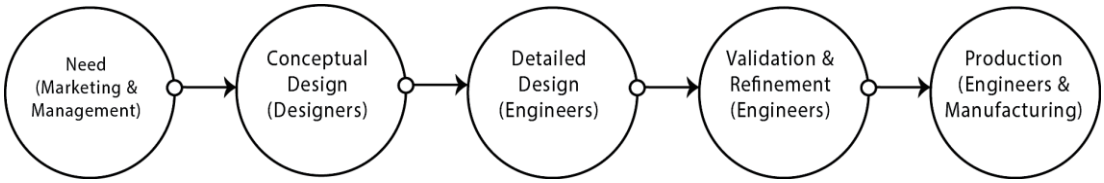


Figure 4 - Roles within the automotive development process (adapted from Sorensen, 2006; Khadani, 2005; Armstrong, 2008; Leaney & Marshal, 2002)

This lack of integration between designers and engineers in development projects is often cited due to the traditionally technology-driven nature of (automotive) engineers who are not accustomed to looking at design from a user centred perspective (Tütek & Ay, 2011; Bergström, 2007; Persson & Warell, 2003). Tütek and Ay argue (2011) that "in order to bring customers 'inside' the company", the conflict that exists between engineering and design must be resolved and "effective integration must be achieved in order to successfully develop and commercialise new products…". It is argued that such conflict limits the ability of automotive manufacturers to continually adapt to changing customer value propositions and needs (Tütek & Ay, 2011), and raises the need for engineers to become more involved with and better understand the role of customer needs and requirements in the total vehicle design process.

Such an argument, whilst seemingly logical at first glance, marginalises engineers through such a black and white perspective, turning the design process into an "us versus them" debate between designers and engineers. This marginalisation of such an important facet of the automotive development process appears rather naïve. Although customer-orientated approaches are typically developed within non-technical departments (i.e. by the designers), such an approach needs to be adopted by the technical (engineering) staff in order for it to be successfully applied in the physical product (Strong, 2014). Whilst lacking in precedent in the automotive industry, the integration of engineers and designers/non-technical divisions into a customer-centric design team has been proved to be successful in the past (Pruitt & Grudin, 2003).

Projects by Microsoft (Pruitt & Grudin, 2003) belie this notion that engineers are unable to engage with designers and user-centric development. The MSN Explorer product development team involved thousands of technical and non-technical staff, including managers, marketers, designers and engineers. This project was able to engage all staff members and disciplines with the focus of a set group of target customers. It was found that the key requirement for engaging all groups, including the engineers, in customer-centric thinking and design practices was through effective communication (Pruitt & Grudin, 2003). The ability for the engineers to understand the user centred thinking from the designers' perspective was facilitated via the use of a design tool known as 'Personas', and is detailed in this literature review in Section 4.4.

Similar to the act of engaging engineers in less technology driven, more user-centric design thinking, the need for designers to connect with other disciplines during the product design process is not a new concept. Norman (2010) initially proposed the need for a transitional engineer/developer to bridge the gap between design and business

thinking within the development process. Wrigley & Bucolo (2012) build on the idea of Norman (2010) for the need for a transitional engineer/developer to bridge the gap between design and business. They suggest that an intermediary translation team could enable the translation of design "knowledge into practical realisations that the team (business) can then develop and deploy" (Wrigley & Bucolo, 2012). Wrigely (2013) further investigates this concept and the skillset required in the form of a design innovation catalyst, outlining the uptake of both business and design skills in a transitional developer to bridge the gap between the disciplines. In proposing the need for a multidisciplinary role for business and design, it is suggested that a similar role could be used to bridge the gap between designers and engineers.

Complementing such roles are design process methodologies for bringing further customer focus into product development. One such well established design method, user centred design, could well serve to promote the new customer-centric business models outlined in Section 2.0. To ensure that automotive manufacturers have the knowledge and flexibility to integrate potentially changing customer requirements into the technical design, is to ensure that user centred design is at the core of all engineering design processes, and that its use is well understood by all engineers (Ward, Runcie & Morris 2009, Bucolo & Matthews 2011).

3.5 Summary

This section explored the vehicle design and development process common to global automotive manufacturers. The examination of the methodology behind vehicle development and its historical foundations further contributed to an awareness of the underlying "technology-driven" culture within automotive manufacturers.

The literature suggested that in spite of projects involving multi-disciplinary teams, they tend to be compartmentalised into discipline-

specific departments, with engineers and designers operating in series, rather than in unison. Furthermore, it became apparent that the technical nature of the automotive industry has led to engineers having "the final say" as to whether proposed designs, such as user centred designs proposed by designers, are feasible, based on technical requirements rather than customer requirements.

Although the literature indicates a precedent of engineers working effectively with designers to adopt design thinking and user centred design methodologies, no documented research describes such an occurrence in the automotive industry. This gap in the understanding of the ability and amiability of automotive engineers to adopt product development approaches traditionally used by designers, such as customer orientated requirements, points to a distinct limitation in existing theory and practice. More specifically, this concerns the effective creation and subsequent use of user centred design frameworks in the vehicle design and development process.

4.0 User Centred Design

4.1 Introduction

Recent years have seen businesses across a wide range of industries transitioning away from a purely technology driven approach through the adaption of their design focus to include the end-user (Oliver Wyman Group, 2007; Hill, 2010; Holt & Cameron, 2010). Such a transition has resulted in the development of methodologies to ensure that designers and developers are creating products that meet users' needs (Lowdermilk, 2013). From the perspective of the automotive manufacturing industry, this has seen experimentation with the implementation of various design tools and methodologies, predominantly by designers and design studios.

Given the broad nature of 'design', summarised by Norman (2004, 225) simply as "a set of choices, some better than others, perhaps none fully satisfactory", it is little wonder that numerous methods, tools and approaches have been applied by designers to try and meet the needs and desires of users in general, and in the automotive industry. This experimentation has come to include vehicle development projects focusing on:

- User-Experience (UX); Knobel et al. (2012) investigated and promoted the importance of vehicles creating positive experiences and fulfilling the psychological needs of users. This approach argues that technological product design should focus primarily on the experience the product provides the user, rather than on its form and functionality.
- Human Computer Interface (HCI); Gellatly et al. (2010) explored the ways in which users interacted with their vehicles, specifically their infotainment systems, in order to refine future designs to provide improved customer experiences. This approach focuses on understanding the context in which products are being used by customers, in order to better

understand and envision future products that are more likely to meet the needs of these contexts.

- Personas; Ford trialled the use of the Persona design tool in their vehicle development process to help visualise the target customers and their needs and requirements in a vehicle (Patton, 2009). This approach looks to develop fictional 'characters' based on customer research data in order to provide a tangible, if limited, reference point for assessing decision in the design process. This tool is often used as part of a design approach known as User Centred Design (UCD), which forms part of the theoretical basis of the research outlined in this thesis.

User centred design can be defined as "a methodology used by developers and designers to ensure they're creating products that meet users' needs" (Lowdermilk, 2013). It focuses on the final product users throughout the planning, design and development stages of a product (User Experience Professionals Association, 2014). More specifically, companies often have a limited understanding of what their customers want, limited to what is immediately observable via interaction with prospective customers which tends towards the solution of short-term needs (Bucolo & Wrigley, 2011). UCD in the context of business innovation provides an opportunity to "develop deeper customer understanding that goes beyond observation", providing a longer-term understanding of customer needs and requirements for driving companies' competitive advantage (Bucolo & Wrigley, 2011).

4.2 The UCD approach

At a general level, the UCD approach is governed by an international standard 'ISO 13407: Human-centred design process'. This standard provides a general process for implementing UCD within a product development lifecycle (International Organization for Standardization,

2010). Commencing with the identification of the need to be met by the use of UCD (see Figure 5 below), the framework involves five general activities to develop a suitably user centred final product (User Experience Professionals Association, 2014; Wallach & Scholz, 2012; HHS Digital Communications Division, 2014):

1. Scope
2. Analyse
3. Design
4. Evaluate
5. Deliver

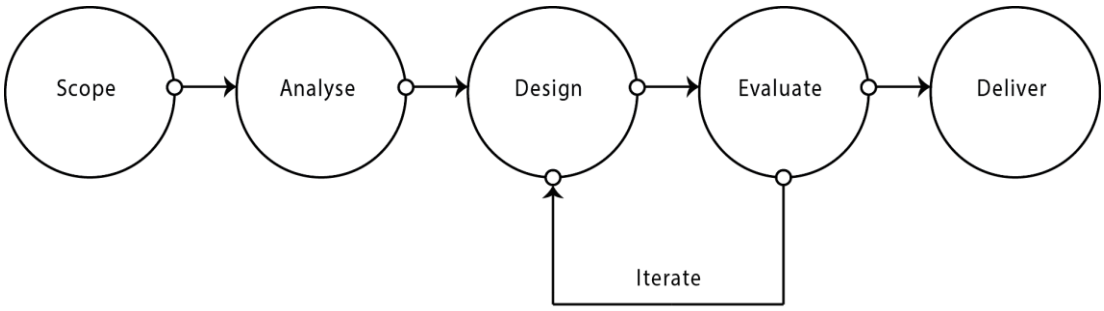


Figure 5 - Generalised UCD framework adapted from User Experience Professionals Association (2014), Wallach & Scholz, (2012), HHS Digital Communications Division (2014)

4.2.1 Scope

During the initial scoping stage, all relevant stakeholders (design, engineering, management, marketing and sales) are brought together to initially establish a common point of reference for the project (Wallach & Scholz, 2012). This common point of understanding is used to allow effective communication between stakeholders at their respective stages in the development process. Communication is facilitated through the shared expectations of the project outcome established in this scoping stage. These expectations are derived from the setting of overarching goals and constraints for the project (Web Accessibility Initiative, 2008).

Goals are established as a group in terms of the desired functionality of the new product and the targeted business outcomes (Wallach & Scholz, 2012). Functionality is defined to the extent by which the product needs to be designed i.e. whether the new product is to be a visual redesign of an existing product or whether the product is something completely new that needs to be developed from the ground up. Similarly, the business goals of the project need to be defined with respect to the target customers. That is, whether the new product is targeting existing customers, or looking to attract new customers.

Similarly, project constraints are established within the scoping phase to minimise the potential for overdesigning an unusable product (Wallach & Scholz, 2012). These constraints typically fall into two categories: technical and contextual. The technical constraints are typically the most restrictive, and are defined by the engineers in order to ensure that design proposals are actually capable of being transformed into physical products within the given time and budget. Additionally, the contextual environment in which the target customers will be operating the product defines the second main constraint to be established. Designers delineate this constraint in order to ensure that the final product design is suitable for the market/s into which it is to be launched.

4.2.2 Analyse

Once a mutual understanding of the overarching objectives is established amongst the project stakeholders, a more detailed analysis of the end-user follows as the next step in the UCD process (HHS Digital Communications Division, 2014). This analysis stage is used to further centralise stakeholder discussion around the needs of actual users, in order to avoid arguments over design based purely on individual/disciplinary opinion (Wallach & Scholz, 2012). It typically commences with the completion of field studies by marketing and

designers in order to learn more about the needs of the target users (User Experience Professionals Association, 2014; HHS Digital Communications Division, 2014). The analyses are then combined with an assessment of competitor products to profile the current products and their usage for a more detailed understanding of the functional and contextual design needs of the new product.

Following the completion of field studies, the detailed, real-customer data is converted by designers into more readily understandable formats for the rest of the project team. This conversion commences with the development of key Personas, which put faces and names to the key customers for whom the product is being designed (User Experience Professionals Association, 2014). In addition to the creation of Personas to better visualise the target customers and their needs, user scenarios and use cases are also developed (HHS Digital Communications Division, 2014).

User scenarios describe the typical interaction of the target customers i.e. the Personas with the product. These scenarios take the form of a story about customer interaction with the product, and are used to identify the user requirements (what user achievements are to be facilitated by the product)(Gaffney, 2014). Similarly, use cases are also developed by the designers to better understand how the end-user is likely to interact with the product. They typically take the form of a series of simple cause-and-effect steps that list the tasks that must be completed by the Persona in order for them to achieve the goal by using the product (Gatherspace, 2014). In contrast to user scenarios however, the use cases are developed to better understand the technical requirements of the proposed product, and are later used by engineers within the design and development process (Gatherspace, 2014; Gaffney, 2014). The documentation of further user and technical requirements from real-life customer contact represents the final step in the analyse stage of UCD.

4.2.3 Design and Evaluate

The aim of the Design stage of UCD is to transform the goals, constraints and requirements from the Scope and Analyse into a finalised product design ready for manufacturing (Wallach & Scholz, 2012). This stage of the UCD process predominantly involves designers and engineers, and is broken down into two distinct design phases: concept design and detailed design (Web Accessibility Initiative, 2008).

The concept design is typically coordinated by designers, and seeks to establish the initial layout of the product and the desired methods of interaction with the user (Wallach & Scholz, 2012). The Personas and Scenarios developed in the Analyse stage form the basis of the conceptual design. They are used to answer the question of 'how' the product meets the functional and non-functional requirements of the customer. Commencing with initial sketches and basic computer modelling such as wire-frames, multiple low-fidelity prototypes are generated from the designers' interpretation of the customer requirements (User Experience Professionals Association, 2014). These tangible conceptual (predominantly visual) designs are evaluated via usability testing with potential customers and discussion with project stakeholders, and the concept design and evaluation process is iterated until a suitable conceptual design is developed.

Upon finalisation of the conceptual design, the engineers are involved to help the designers work towards a detailed design. This phase requires the specification of all individual components in the product. These components are designed to individually meet the required needs of the customer whilst fitting into the overall product concept previously developed by the designers. As the detailed design is finalised, a high-fidelity prototype i.e. a model of the proposed finished product is produced (Web Accessibility Initiative, 2008). This prototype is evaluated via usability testing with potential customers and

discussion with project stakeholders, and the detailed design and evaluation process is iterated until a suitable detailed design is developed that meets customer and project requirements.

4.2.4 Deliver

Representing the end of the UCD process, the finalised detailed design is subsequently passed onto the product delivery team for implementation (Wallach & Scholz, 2012). The design team works closely with the delivery team, ensuring that adequate instructions are provided to allow for the appropriate reproduction of the detailed design as a finished product. This concludes the UCD process, ideally culminating in a product that meets the functional and emotional needs of the customer, and the business and technical requirements specified by the project stakeholders (Lowdermilk, 2013).

4.3 Reservations and concerns

Although the use of UCD in business design processes has been typically seen as a positive step towards more desirable and functional customer centric products (Giacomin, 2012; Vredenburg, Isensee & Righi, 2002; Abras, Maloney-Krichmar & Preece, 2004; Gulliksen et al., 2003; Vredenburg et al., 2002), some reservations have been raised by the approach. There appear to be three main concerns regarding the use of UCD:

- The singular focus on the user above all else (including the activity to be completed by the product) in UCD can potentially result in unnecessarily complex and less functional designs (Norman, 2005).
- The influence of self-reference and bias of the designers on the customer requirements that are developed using UCD (Steen, 2012).
- The reality concerning the level of UCD implementation within businesses (Gulliksen, Lantz & Boivie, 1999; Vredenburg et al., 2002).

These three concerns are addressed below.

Don Norman (2005) raised the concern of UCD having now become automatically accepted as the standard approach when considering many new product designs. He suggested that the primary focus of UCD on the user could potentially result in less functional products. This is namely due to the potential for designers to disregard the importance of the actual activity to be completed by the product when focusing heavily on the customer during the design process. However, whilst this certainly has the potential to occur, it can be argued that when UCD is part of a multidisciplinary approach to product development, it must take into consideration a range of other requirements (such as technical, functional and business)(User Experience Professionals Association, 2014). This is due to the fact that designers and UCD are typically not operating in a vacuum, but rather as part of a larger business seeking to develop a new product (Wallach & Scholz, 2012).

A second criticism of the UCD approach points to potential issues with those using UCD methodology rather than with UCD in of itself. That is, the issue of designers unconsciously imparting personal bias and self-referencing on the overall design under the guise of user-centrism (Steen, 2012). Whilst certainly a valid concern, that UCD products are not actually user centred but rather designer-centred due to designing for what they feel the users would want rather than the reality, this would only be a problem if UCD methodology is not being adhered to. More specifically, as outlined in Section 4.2.2, the Analyse stage of UCD specifically aims to interact with real users and gather real-life data rather than assumed customer behaviour (Wallach & Scholz, 2012). In light of this, UCD could only fall prey to self-reference and bias if those implementing it were not strictly following the approach that is UCD.

Lastly, the degree to which UCD is implemented within any given business or project has been raised as a potential cause for concern (Gulliksen, Lantz & Boivie, 1999; Vredenburg et al., 2002). Whilst not strictly a concern regarding UCD itself, if UCD is only informally applied to parts of projects (Hudson, 2001), this does raise the issue of the potential benefit of UCD to businesses if it is not properly implemented. Gulliksen et al. (2003) argue that this lack of proper implementation is ultimately due to a lack of understanding of the benefits of UCD and how to apply the approach. They (Gulliksen et al., 2003) suggest that the proper implementation of UCD ultimately requires the presence of knowledgeable UCD users who are capable of showing the benefits of UCD within a product design process in order to gain overarching support. Furthermore, this implementation needs to gain the support of management in order to bring together operational and strategic decisions for a holistic approach to the process (Bucolo & Matthews, 2011).

Despite the reservations and concerns about UCD raised in this sub-section, the general consensus appears to be quite positive towards its use and successful implementation. One particular tool frequently used within UCD has seen recent success in addressing these issues, especially in the automotive manufacturing industry (Patton, 2009), and forms a key part of the foundations of the research upon which this thesis is built. That is, Personas.

4.4 Personas

4.4.1 Definition

Personas are typically defined as "fictional, detailed archetypical characters that represent distinct groupings of behaviours, goals and motivations" (Calde, Goodwin & Reimann 2002) which act as 'stand-ins' for real users and help to guide decisions about functionality and design (Calabria, 2005). They are often used when designers are unable to continuously engage directly with end-users, be it due to

time, money or other project constraints (Marshall et al. 2013). Personas are based on knowledge of real users garnered from user-research, and help to identify customer motivations, expectations and goals with regards to the target product segment (e.g. automobile usage). The development of personas as a focus tool used, for example, in vehicular design, personalises target customers in the minds of employees, removing the disconnection in the design process between the customer and the product developer.

"Personas summarize user research findings and bring that research to life in such a way that everyone can make decisions based on these personas, not based on themselves" (Mulder & Yaar, 2007, 19). This allows for a design to take multiple stakeholder perspectives into consideration in terms of final product design. Furthermore, the persona design process (typically comprising 1-7 personas) focuses on the difference in goals and behaviours of potential customers, allowing the design team to place less emphasis on the need to develop a perfect solution for a particular demographic or market segment (Marshall et al. 2013).

4.4.2 Development and Implementation

With personas helping to develop a precise description of the user and what they wish to accomplish (Cooper, 2004), the first step in achieving this understanding requires the collection of data regarding the target product users (Miaskiewicz & Kozar, 2011; Wrigley, 2014). Data can be collected via multiple channels (Calabria, 2005):

- Interviews & ethnography; interview existing and prospective customers regarding their needs, requirements and attitudes towards the proposed concept, and use ethnography to understand any cultural impacts or needs of target users;

- Surveys; survey existing and prospective customers to identify trends in behaviour and usage within certain demographics, and;
- Market research; review existing market research or commission new market research to understand the goals, behaviours and attitudes shown by customers in the target market.

Following the collection of data, the data is analysed for patterns in the goals, behaviours and attitudes of the users (Cooper, 2004). These patterns are then clustered together, with recurring goals, behaviours and attitudes from the data forming the basis for individual personas (Calabria, 2005). If there are too many clusters i.e. more than 1-7 personas (Marshall et al., 2013), similar groupings of goals, behaviours and attitudes are merged to reduce the number of personas.

With the analysis of the target user data completed, the final step in persona development is the write-up of the clustered data into specific personas (Cooper, 2004). This write-up focuses primarily on the central goals of individual groups, and to a lesser extent on the behaviours and attitudes of types of users, with regards to the product concept (Mulder & Yaar, 2007). These write-ups aim to develop 1-3 primary personas, the main users being designed for who must be satisfied, and secondary personas who will also use the product, but for whom the design specifics are considered less vital (Cooper, 2004). The final personas can be represented in many forms dependent on the needs of the project, or the culture of the organisation or project team, with some represented in a detailed, story-like format (Figure 6), and others merely as a brief table of specifics (Figure 7). These personas are not static, but are regularly updated in order to ensure that they remain relevant under changing economic and societal conditions.

George is 28 years old and works as an electrician within a firm offering in-home service when they are having home wiring issues. He has worked for the company for the last 10 years, graduating from an apprenticeship to full-fledged electrician. George looks after many of the apprentices when they are all working on site together, and knows many tips and tricks at quickly solving everyday electrical problems. George likes helping out the apprentices, as he feels it's his way of giving back after learning so much during his own apprenticeship.

George works flexible hours, and is often on-call out of hours to deal with single-home power outages and issues that result in a single home or apartment losing power. About 15% of the call-outs he attends are complex, and requires that he refer to his firm's trouble-shooting database. George takes pride in briefly talking customers through their electrical issue as he feels it helps them better understand his skills and the service he is providing them.

George has seen his firm evolve with the onset of new technologies, and seeks training wherever possible to stay on top of the latest changes and development. He really enjoys the challenge of learning new approaches to his trade, and tries to pass on his enthusiasm to new apprentices who are often daunted by all that they need to learn, let alone new techniques and technologies.

George's been told he can take over training the next batch of apprentices in these new techniques. He feels comfortable with the idea, but is unsure as to what the more senior electricians at the firm will think of someone so young taking over some of the apprentices' training. He takes pride in his teaching abilities, but has often had issues with his seniors ridiculing him about it because of his age.

George wonders whether things will change when he starts teaching the new apprentices. He doesn't mind the occasional comment from his older colleagues, but hopes that this new development won't affect their friendly working relationships.

Figure 6 - Detailed example of a persona adapted from Calabria (2005); photo is from creative commons

Electrician

Work experience	10 years
Job description	Deals with call-outs to homes (approximately 15% of issues are complex and require reference to new technology databases, the rest are normal issues) Helps to make apprentice electricians more at ease at work
Likes	Being up to data with the latest electrical technologies and passing on knowledge to the apprentices Educating customers about what is going on
Dislikes	Being talked down to because of his age Having to juggle senior colleague amiability with wanting to train apprentices
Aims	Stay up to date with the latest electrician trends and technologies Be seen as an apt teacher for apprentices Maintain good relations with senior colleagues

Figure 7 - Minimalistic example of a persona adapted from Calabria (2005)

With the user data collated, analysed and developed into personas representing key customer groups, the personas are ready to be implemented within a design project. Personas can be used to (Cooper, 2004; Calabria, 2005; Mulder & Yaar, 2007):

- Identify required product features and functionality;
- Facilitate communication between company management and the design team regarding the vision for the product and how it will meet the needs of the customer;
- Centralise multidisciplinary design discussions on the needs and requirements of the user, rather than of those perceived by individual project team members;
- Develop scenarios for usability testing, and;
- Complement sales & marketing efforts surrounding the product.

Ultimately, the personas focus product discussion within the firm around the end-user and their needs in an attempt to produce products that provide a more enjoyable and functional design (Cooper, 2004).

4.4.3 Theory

Bucolo & Matthews (2010) focus on how a design methodology, which includes experiments with personas, translated customer experiences into ideas and conceptualisations for future product development. The creation of personas within research and design teams was seen to provide a graphical representation of customers and their needs, which enabled the swift generation of ideas and unification of multidisciplinary groups of employees behind these ideas. This success was attributed to the ability of personas to facilitate 'role playing' by employees from various disciplinary backgrounds, which helped to overcome individual employee perspectives and understand the context of a problem from a user's perspective.

Research by Goel, Smith, & West (2005) discuss the use of personas as a design tool to allow engineers and designers to "remember what we are trying to accomplish" when faced with a project that consists of hundreds, or even thousands, of technical project requirements. This allows for the overall design to focus on what the customers need, rather than what might be used. In this same, Miaskiewicz & Kozar (2011) argue that the most significant benefit of personas is their ability to focus product design teams on the actual goals of the target customers. Furthermore, personas focus the design effort on supporting customer needs and requirements, rather than being driven by the ideas of team members. This helps to address concern of self-reference and helps to minimise potentially undesirable design elements (such as large numbers of unused "stock or optional extras") that can often arise due to the technology-driven focus of engineers with the design team (Calabria, 2005).

However, such a design tool as personas are typically utilised by designers during the conceptual design phase, with engineers tending to follow the traditional engineering design process to analyse the conceptual design and develop it into a detailed design (see Section 3.3). Similar to the software programmers outlined by Cooper (2004), engineers are often reluctant to become involved in such design practices which are developed by multidisciplinary "seat at the table" design approaches. This often results in the engineers, who have ultimate control over the technical design and thus the majority of the final vehicular product, driving the team from the back seat based upon their engineering-based goals and concerns (Cooper 2004). Such issues of designer-centrism are further outlined in Section 4.5, highlighting the current use of UCD in practice and the additional opportunities to be gained from its use.

4.5 UCD in practice

Since its initial development from previous design methods in the 1980s (Gould & Lewis, 1985), UCD has seen widespread implementation in a diverse range of companies. However, the origins of UCD and its tools lie heavily within the software development industry (Gould & Lewis, 1985; Cooper, 2004), and it is here that examples of fully integrated UCD will be examined in the context of the product development process. Similarly, with the focus of the research on the automotive industry, examples of UCD application in the automotive manufacturing industry will be examined and compared with these fully integrated software design examples.

From a software design perspective, Microsoft represents a keen adopter of the UCD approach and its tools, having successfully completed a number of projects using UCD, including those for MSN Explorer (Wang, 2007), Visual Studio (Webber, Manning & McInnes, 2007) and Windows (Pruitt & Grudin, 2006). These projects were a result of Microsoft's desire to improve the usefulness, usability and desirability of its software offerings through a better understanding of their users. The use of personas also featured heavily as a key tool to facilitate the UCD process.

The Windows project commenced in 2001 and was a multidisciplinary collaboration actively involving such disciplines as engineering, management, design, user research and marketing (Pruitt & Grudin, 2006). Implementation of UCD was predominantly through the use of Personas, but was supported by participatory & contextual design and ethnography for user data collection and analysis, in addition to scenarios and task analyses to better convey the product use by the personas. The underlying reasoning for UCD implementation was based on the objective of helping the product development team identify and understand its target audience and subsequently aiding in the making of design and development decisions (Pruitt & Grudin,

2006). Unlike an earlier attempt with the MSN Explorer project, the Windows project involved the use of Personas and subsequent storytelling and scenarios from the very beginning of the project. These Personas were adopted by all stakeholders – designers, managers, engineers, and marketers – and helped to facilitate effective communication between the groups. They also helped to ensure that any feature, strategy or implementation decision was grounded in its use and functionality in the hands of the target customers (Pruitt & Grundin, 2006). Whilst no quantitative data was available concerning the positive impact of UCD on the project, within the Windows project the use of UCD was found to have greatly increased the engagement of stakeholders in the need for user-focus and in communicating ideas and requirements between the different disciplines.

From an automotive industry perspective the use of UCD in the product development process is more recent. Four major manufacturers have recently experimented with focusing on the end-user within their design processes, but to a varying extent often focused on one aspect of the vehicle design. General Motors sought to gain a deeper understanding of how their drivers interacted with their in-car infotainment systems, in order to better tailor the design of these systems to the everyday General Motors vehicle user (Gellatly et al., 2010). Similarly, BMW experimented with the social aspect of vehicle-user interaction, attempting to better understand the potential for social media to influence the use and experience of their vehicles by prospective customers (Knobel et al., 2012). Nissan's trialling of UCD has only extended so far as contracting out research into current and anticipated usage behaviour of certain customer markets, culminating in the compilation of personas given to the in-house design team (Marshall et al., 2013). Finally, of the four automotive manufacturers to implement UCD or UCD tools, Ford has come the closest to complete integration within the vehicle design process.

In seeking to develop a Ford Fiesta design palatable in all their major markets, Ford centralised the design process around the customer through the use of Personas and storytelling (Patton, 2009). Through the compilation and assessment of demographic research into the target Fiesta customers, Ford developed a handful of Personas, complete with psychological profiles. These characters were used to "get everyone on the same page", in order to ensure the designers were not just designing for themselves but rather for the customer and end-user (Patton, 2009). However, in spite of the strong sales success of this UCD Ford Fiesta (Patton, 2009), the implementation of the UCD approach appears to have been given solely into the hands of the designers in the Ford design studio.

In spite of this apparent move towards a user centred approach to automotive project design and development, this project appears similar to many automotive design "success stories", such as the design of Ford's successful 2005 Mustang (Tischler, 2004). More specifically, such projects are predominantly design-centric, divorcing themselves from the reality of the multi-disciplinary nature of automotive vehicle development, where designers and engineers are both required to successfully manufacture a vehicle. Whilst this cannot be entirely the case, as such projects go on to develop fully-functional products despite the apparent backgrounding of the developmental engineers, such articles highlight the current absence of the engineer from the design process, at least from the perspective of automotive design.

This suggests, that there is significant potential for further success if customer needs and requirements were to be placed at the forefront of the engineering design process. The adoption of personas by engineers in addition to designers at firms such as Ford represents a first potential step towards a customer centred approach to vehicular design and development. This problem represents a key issue for the

successful implementation of UCD in automotive manufacturing companies, and thus for their potential competitive edge in the global automotive industry.

4.6 Summary

User centred design has increasingly been implemented in the design and development process by designers as firms transition towards more user-orientated approaches to product development. This approach takes into account the entire design process, from conception through to production, focusing on understanding the needs and requirements of the user and how product designs can meet these needs within a company setting.

UCD implementation within industry has traditionally been tied to software development projects, but automotive manufacturers have started to experiment with its use in vehicle design. This experimentation with UCD by automotive manufacturers through the use of Persona and storytelling tools heavily influenced the design of the commercially successful seventh generation Ford Fiesta (Patton, 2009). However, detailed examination of the available literature shows that this adoption of UCD in vehicle development is predominantly limited to use by designers within separate design studios, rather than as part of a holistic, multidisciplinary design and development process.

With software firms such as Microsoft having shown that the inclusion of engineers within UCD frameworks is both possible and results in positive design results, the absence of research into UCD adoption by automotive engineers suggests a key gap in the literature. As engineers have been show to play a vital role in the vehicle design and development process, a gap in the theoretical and commercial understanding of UCD use by engineers represents both a knowledge gap and a research opportunity to be explored.

5.0 Literature Gap

5.1 Summary of Literature Review

The main fields of literature examined to help contextualise the research include the automotive industry, the vehicle design and development process, and user centred design.

Literature pertaining to the automotive industry reflected upon the historical development of automotive manufacturers, the contemporary challenges faced by companies in remaining competitive, and the attempts by manufacturers to overcome these challenges through adaptation of their business models. The historically technology driven automotive industry was shown to be facing increased competition in traditional markets where sales were stagnating and companies had similar levels of technological expertise. In response to these challenges, it was shown that some manufacturers were looking to adopt more customer-orientated approaches to vehicle design and production in order to gain an edge on the competition. However, existing literature in the adoption of user centred approaches in the automotive industry is currently limited to its use by designers and their projects. This pointed to a gap in the literature regarding its wider application in the vehicle design and development process due to lack of inclusion of engineers in existing user centred approaches in the industry.

From the perspective of vehicle design and development, the literature explored the current framework used by automotive manufacturers, and the underlying "technology-driven" culture within automotive manufacturers that became established as a result of this approach. The literature also suggested that in spite of projects involving multi-disciplinary teams, they tend to be compartmentalised into discipline-specific departments, with engineers and designers operating in series, rather than in unison. Literature further indicated a precedent of engineers working effectively with designers to adopt

design thinking and user centred design methodologies, although there was found to be a gap in existing literature concerning such an occurrence in the automotive industry. This gap this concerns the effective creation and subsequent widespread use of user centred design frameworks in the vehicle design and development process.

Finally, the theoretical concept of user centred design and its industrial applications were explored. UCD has been successfully implemented in commercial product development, especially within the software industry. Automotive manufacturers were also found to have experimented with the application of UCD in their vehicle design processes, although to a more limited extent. Review of the available literature showed that UCD implementation in automotive manufacturers was limited to use by designers in design departments. This absence of interdisciplinary use of UCD, especially by automotive engineers, was found to be a significant gap in understanding how to effectively adapt a UCD framework in automotive manufacturers to facilitate the production of more customer-orientated vehicles.

5.2 Existing Gaps

From an examination of the literature pertinent to the research addressed in this thesis and its subsequent summary in Section 5.0, it has become apparent that there are certain gaps in the available research. These gaps pertain to the adoption of user centred approaches within the vehicle design and development frameworks of automotive manufacturers. Given the research question seeks to examine the challenges and opportunities facing the implementation of a UCD approach i.e. the gaps in the literature, successful completion of the research should contribute to better theoretical and commercial understanding of user centred *engineering* in vehicle design and development.

More specifically, how to feasibly and effectively implement a widespread UCD approach and mentality to vehicle production

within an automotive manufacturer. Available literature examines the use of customer orientated design approaches such as UCD within automotive manufacturers (Knobel et al., 2012; Tscheligi, 2012; Gellatly et al., 2010; Patton, 2009), however this research was limited to design methodology use by designers within the respective firms. Given the focus of design for designers in the literature, additional research is needed to understand the practical and cultural challenges in implementing similar approaches throughout the vehicle development process i.e. with automotive engineers.

In short, it was identified from the main gaps in the existing literature, which is broken down by focus area in Table 1, that:

- Despite industry trends driving customer-centred approaches, there is limited research concerning the implementation of UCD as a new business model strategy in the automotive sector.
- UCD implementation in the automotive industry has been restricted to use by designers, and further research is required to understand the challenges in companywide adoption, especially amongst the key staff, engineers.
- Further research is needed to develop potential frameworks to effectively adapt existing vehicle design and development processes to a UCD approach.

Table 1 outlines these gaps with respect to the literature that was sourced and to the following underlying research questions that seek to address these gaps:

- RQ: What are the key challenges and opportunities in seeking to successfully integrate user centred design through the adoption and implementation of personas in an automotive manufacturing company culture?

- *Sub-RQ 1: What stereotypes exist that may act as barriers towards the use of personas and user centred design by engineers in the company?*
- *Sub-RQ 2: What benefits are provided to the technical design process by the adoption by engineers of user centred design within complex automotive manufacturing projects?*

Table 1 – Literature themes, sources and relation to research questions

		RQ	Sub-RQ 1	Sub-RQ 2
Automotive Industry	Accenture, 2010; ACEA, 2012; Ali, Gafar & Akbar, 2013; Armstrong, 2008; Barnard, 2002; Beecroft, 1927; Bhimani & Mulder, 2001; Clarke, 2003; Deloitte, 2008; Deloitte, 2009; Deloitte, 2009a; Design Museum, 2013; Dreyer, 2009; Fink, 1990; Ford, 1922; Gunasekaran & Ngai, 2005; IBM, 2012; Jaafarnia & Bass, 2011; Jaikumar, 1986; James, 1928; Khandani, 2005; Klepper, 2001; Knobel et al., 2012; Leonard, 2014; McKinsey, 2013; McKinsey, 2014; Moore, 1998; National Academy of Engineering, 2014; Parry & Graves, 2008; Parry & Roehrich, 2013; Patton, 2009; Ramsey, 2013; Shehab & Abdalla, 2001; Soderberg, 1989; Sorensen, 2006; Stastista, 2014; Tscheligi, 2012; U.S. Library of Congress, 2014; University of Colorado Boulder, 2014; Wells, 2013			
Automotive Design	Accenture, 2010; Armstrong, 2008; Clark, Chew & Fujimoto, 1987; Design Museum, 2013; Gellatly et al., 2010; Gunasekaran & Ngai, 2005; Khandani, 2005; Knobel et al., 2012; Leaney & Marshall, 2002; Oliver Wyman Group, 2007; Parry & Graves, 2008; Parry & Roehrich, 2013; Patton, 2009; Ramsey, 2013; Satake et al., 2011; Sorensen, 2006; Stastista, 2014; Strong, 2014; Tischler, 2004; Tscheligi, 2012; Viswanathan, 2013			
Business models	Dreyer, 2009; IBM, 2012; Leonard, 2014; National Academy of Engineering, 2014; Osterwalder & Pigneur, 2010; Parry & Graves, 2008; Parry & Roehrich, 2013; Wells, 2013; Zott & Amit, 2010			
Customer Orientated Approaches	Abras, Maloney-Krichmar & Preece, 2004; Ali, Gafar & Akbar, 2013; Bucolo & Matthews 2011; Bucolo & Matthews, 2010; Cooper, 2004; Dell'Era, Marchesi & Verganti, 2010; Gaffney, 2014; Gatherspace, 2014; Gellatly et al., 2010; Giacomin, 2012; Gould & Lewis, 1985; Gulliksen et al., 2003; Gulliksen, Lantz & Boivie, 1999; Gunasekaran & Ngai, 2005; HHS Digital Communications Division, 2014; Hill, 2010; Holt & Cameron, 2010; Hudson, 2001; Jaafarnia & Bass, 2011; Knobel et al., 2012; Lowdermilk, 2013; Mattison, 2006; Norman, 2004; Norman, 2005; Norman, 2010; Patton, 2009; Steen, 2012; Tscheligi, 2012; User Experience Professionals Association, 2014; Vredenburg et al., 2002; Vredenburg, Isensee & Righi, 2002; Wallach & Scholz, 2012; Ward, Runcie & Morris 2009; Web Accessibility Initiative, 2008; Wrigley & Bucolo, 2012			
Applied UCD	Bergström, 2007, Bucolo & Matthews, 2010; Gellatly et al., 2010; International Organization for Standardization, 2010; Jaafarnia & Bass, 2011; Knobel et al., 2012; Patton, 2009; Persson & Warell, 2003; Pruitt & Grudin, 2003; Tischler, 2004;			

	Tscheligi, 2012; Tütek & Ay, 2011; Wang, 2007; Webber, Manning & McInnes, 2007	
Personas	Calabria 2005; Calde, Goodwin & Reimann 2002; Cooper, 2004; Gatherspace, 2014; Goel, Smith, & West, 2005; Marshall et al. 2013; Miaskiewicz & Kozar, 2011; Patton, 2009; Pruitt & Grudin, 2003	

Table 2 seeks to further visualise the aforementioned gaps in the literature, by grouping key research contributions to the literature with respect to any existing overlap of research into multiple areas addressed in the literature review. This table helps to outline the areas of complimentary research that has yet to be conducted and which has subsequently contributed to the existing gaps in the literature.

Table 2 - Overview of existing literature overlap

	Automotive Industry	Automotive Design	Business Models	Customer Orientated Approaches	Applied UCD	Personas
Accenture (2010)						
Armstrong (2008)						
Patton (2009)						
Sorenson (2006)						
Khadani (2005)						
Parry & Graves (2008)						
Parry & Roehrlich (2013)						
Design Museum (2013)						
Wells (2013)						
Knobel et al. (2012)						
IBM (2012)						
Cooper (2004)						
Pruitt & Grudin (2003)						
Gellatly et al. (2010)						
Bucolo & Matthews						

(2010)						
RQ						
Sub-RQ 1						
Sub-RQ 2						

6.0 Case Study

6.1 Introduction

In order to contextualise the research and outline its origins and motivations, a suitable background must be provided of the case firm with whom the research was undertaken. This chapter will endeavour to provide the market, operational and design process details of the firm and the historical steps that lead to its collaboration with the university. However, the research is bound by ethical agreements and some of the information is proprietary in nature, so some details will not be disclosed in the research. Additionally, the chapter will investigate previous attempts by the firm to shift towards a more customer-centred development process, in order to better understand the current opportunities and challenges facing the implementation of UCD within the firm.

6.2 History

Representing one of the largest and most successful car companies in the world, the case firm is a German automotive manufacturer, with over 100 000 employees globally, who designs and produces vehicles for the luxury car market. Whilst a historical success in its traditional markets of Europe and North America, the firm has recently turned towards developing markets to overcome stagnating sales in these traditional markets.

Traded as a public company, company operations are divided into a large number of departments and sub-departments (see Figure 8) by vehicle model (line departments) or by functional area (e.g. drivetrains, chassis etc.), in addition to departments for marketing, sales and other organisational requirements. The majority of operations, including the design and development of most vehicle models, take place in Germany, with the majority of employees coming from a technical, engineering background. As a result, the design and development process is the epitome of technical

excellence and quality, but is heavily influenced and driven by this technical background.

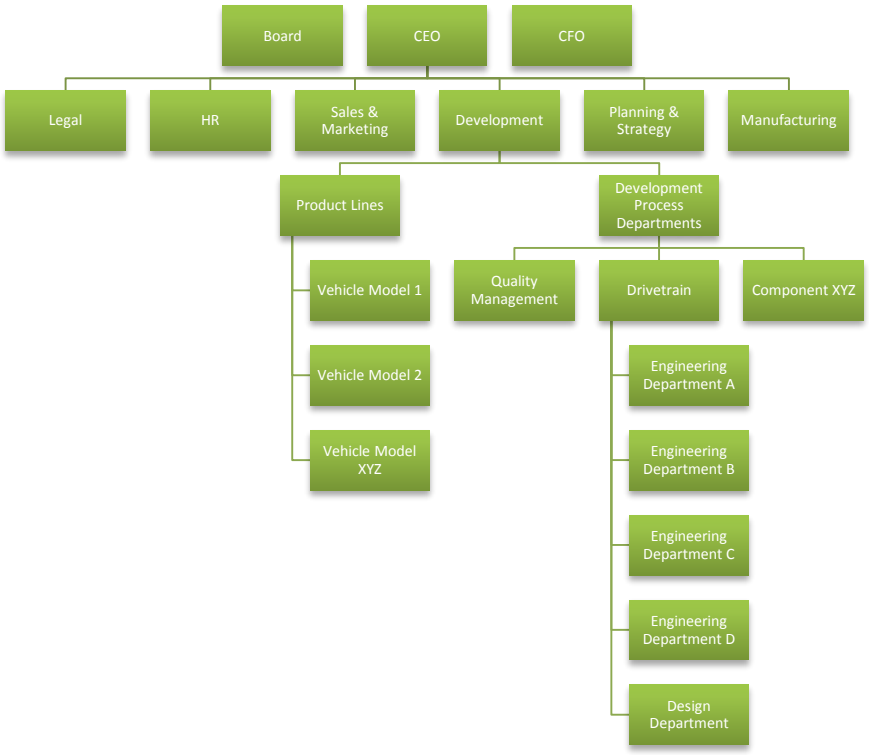


Figure 8 - Condensed approximation of case firm hierarchical structure

6.2.1 Drive to change

Recent shifts towards new business models in the automotive market are nothing new for the firm. Neither is the concept of a customer centred approach. This approach typically comprised of detailed research to understand their customers, with the information used to guide business, design and development, and marketing decisions throughout the firm. Beginning in the late 1990s this increased awareness of changing customer needs lead to a significant rebranding of the customer and greater segmentation of its product offerings. Such ambitious vision towards needing to understand their customers resulted in the continued market leading status of the firm.

More recently this ambition towards better engagement with the customer has been further entrenched in the culture of the firm through the foundation of core principles for the guiding of company

strategy and operations. The first of these principles is that of 'customer orientation', the goal of which is to have "the right products and the right technologies" for their customers. That is, aligning their products and services to the needs of their customers around the world to provide a "delightful" customer experience. In light of this, the firm has established relationships with experts such as Don Norman and Marc Hassenzahl in an attempt to bring further expertise and insights in the fields of user experience and product usability into the firm.

Similarly, the firm tentatively engaged with the university prior to the involvement of the researcher. This relationship was driven by a senior manager at the firm looking to establish links with the university in Australia. However, it was the connection of a quality management engineer within the firm and university representatives that raised the potential for further developing the application of user centred thinking into the design and development process of the firm. This resulted in the possibility for a masters student to engage directly with the engineer to investigate the potential for UCD to be more greatly adopted by engineers within the vehicle development process.

At heart a technology-driven company, this recent shift towards customer-centrism has influenced more than sales, marketing and design departments within the firm. This culminates in their engineering of a development process designed to allow for the complete customisation of vehicles by prospective customers. The firm provides the opportunity for customers to select from thousands of component options to completely customise their vehicle, with the objective of 'zero defects' in their finished products. However, as raised by Gunasekaran & Ngai (2005) and the Oliver Wyman Group (2007), allowing customers to choose from a wide variety of components to build their vehicle does not necessarily reflect a user centred approach, but rather a technology-driven development process. This apparent disconnect between the good intentions of the firm and the

reality in bringing the end-user "inside" the firm requires greater understanding of their current approach to vehicle design and development.

6.2.2 Vehicle design and development

Given the size of the firm and the complexity of the products it offers, the approach of the firm towards vehicle design and development has become heavily departmentalised and institutionalised over time. This institutionalisation has led to a significantly top-down approach to the development process. Decisions concerning vehicle development are often made by senior managers and passed down to the departments with little input from those involved in the actual development process. Furthermore, departmentalisation within the firm results in the design and engineering of individual vehicle components (or parts thereof) in complete isolation from one another. This departmental isolation has become so institutionalised that an entire department has been formed to act as a liaison between designers and engineers working on the same project.

Similarly, the design and development process of the firm (see Figure 9) poses a further challenge to the integration of UCD throughout the development. That is, the process is heavily influenced by the traditionally technology-driven approach of the firm to vehicle manufacturing, as demonstrated earlier by the generalised automotive development process in in Figure 3. This technology focus is also evident in Figure 9 from the positioning of the customer centred phase separate to the technical phases in the development process. Moreover, the traditionally customer orientated product design phase is heavily influenced by the technological mentality within the firm.

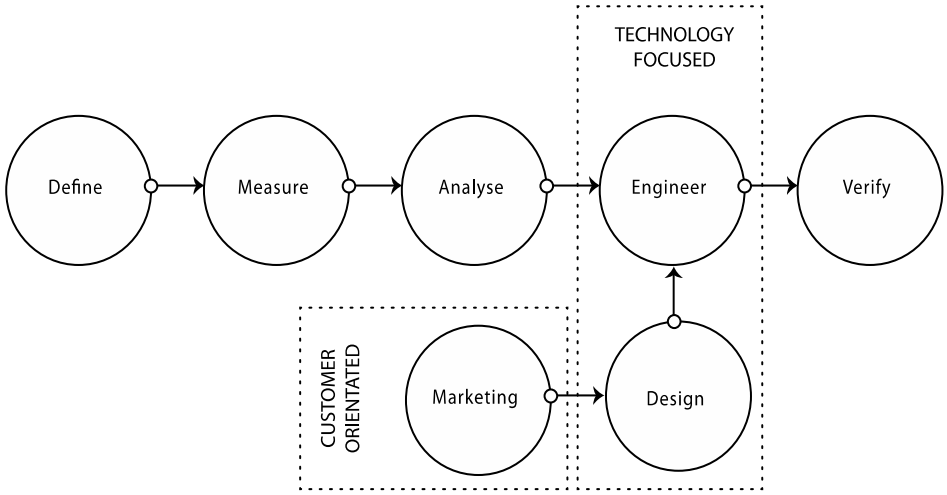


Figure 9 – Automotive design and development process observed within case firm

Following the project definition by senior management in the 'Planning & Strategy', 'Development', 'Manufacturing' and 'Sales & Marketing' departments (see Figure 9), measurement and analysis of potential technical vehicle requirements are undertaken by engineers within sub-departments of 'Development' prior to any attempts at developing a vehicle design. This effectively limits the design space to operate within the realms of the previously defined technical requirements. Furthermore, with the final design controlled by engineers, and designer input predominantly entering the process at a late stage of development, the opportunity for customer centred input into the vehicle is currently quite limited when following the existing methodology.

A key challenge represented by this institutionalised development process is ensuring the final product meets customer requirements. With the initial stages of vehicle development dominated by technical requirements, successfully implementing UCD would require a substantial change to traditional firm practices. As one participant decried "we have no time to do additional work", whilst another voiced a common concern regarding change "I've always done it like this, I can't do it any other way".

It is barriers such as these that must be addressed if UCD and true user requirements are to be incorporated into the vehicle development process of the firm. However, the current environment within the firm reflects a significant opportunity to take up the challenge. The recently introduced company-wide 'customer orientated' strategy signals a potential new chapter in the history of the firm. It is certainly one that offers a unique opportunity for the integration of the benefits provided by UCD thinking into the entire vehicle development process, rather than just within the design departments, through the development of a new design and development process.

6.2.3 Company Mentality

To understand the company culture and thinking that pervades the firm and its practices, this sub-section will seek to outline the history of this mentality and how it influences the shift towards customer-centrism. With a history of technologically innovative and superior products tracing back to the beginning of the 20th century, the firm has long been associated with technical excellence and performance, often closely tied to its German engineering and manufacturing roots. As a result of this, the development and production process came to be dominated by a focus on engineering quality and performance, emphasising the importance of engineers and engineering departments within the firm. This emphasis was in turn reflected in their approach to the vehicle design and development process, becoming centralised around the need for product designs to meet 'technical requirements'

This German engineering excellence has historically served the firm well, and established itself as a leading global automotive manufacturing. However, recent expansion into new markets such as China, has required a substantial revision of institutionalised assumptions. Most important of which is that vehicles based on technology driven German engineering are not by themselves

adequate to penetrate these new customer markets. Such attempts to enter new markets has led the firm to look for new approaches to their business model in order to maintain their dominant position as a luxury automotive manufacturer.

This new approach has taken the form of a customer orientated approach to vehicle production. As one participant remarked, this requires a "mind change" away from the technology dominated thinking current institutionalised within the firm. Whilst such a shift in thinking appears to have been adopted by the sales and marketing departments, and the products designers within the firm, it has yet to take hold within the engineering departments at the core of the automotive development process. The following sub-section looks to address the importance of facilitating a mind change within the engineers of the firm and the conditions in which the researcher set about assessing the challenges and opportunities faced by the introduction of UCD.

6.3 Engineering change

Stemming from a top-down management initiative to better orientate firm product development around the needs of the user, the shift in thinking within the firm has yet to fully take-hold within the engineering departments involved in vehicle design. The engineers within these departments typically have the final say over the vehicle design; measuring it against technical-requirements they receive from engineering management to determine its suitability. In spite of this, the push for a more customer centric mentality has struck a chord with individuals within these engineering departments. These individual engineers have been engaged with more multidisciplinary project (design) teams, and have come to appreciate the potential advantages provided by adopting a user centred approach to the design process.

6.3.1 Initial steps

This engagement of firm engineers in a research project with company designers concerning user centred design catalysed one engineer, working within the quality control department for vehicle development, to contemplate a wider application of this approach within the firm. Initial investigative steps over the course of 2012 resulted in the preliminary development of personas, known as 'customer profiles', for one vehicle model in three key markets. The long-term objective of these personas was to use them as stimulus for the generation of customer requirements, customer interaction studies and vehicle usage scenarios within the design and development process.

The personas were developed from an analysis of the following data for each of the key markets:

- Production and sales figures;
- Climate and geographical environment;
- Social environment of target customer;
- Vehicle usage and user behaviour data (from previously recorded vehicle data logging in a similar environment by a similar user), and;
- Emotional behaviour and psychological needs of the customer.

The analysis of this quantitative and qualitative data led to the initial creation of three personas, one for each target market, similar to the example template provided in Figure 10 below.

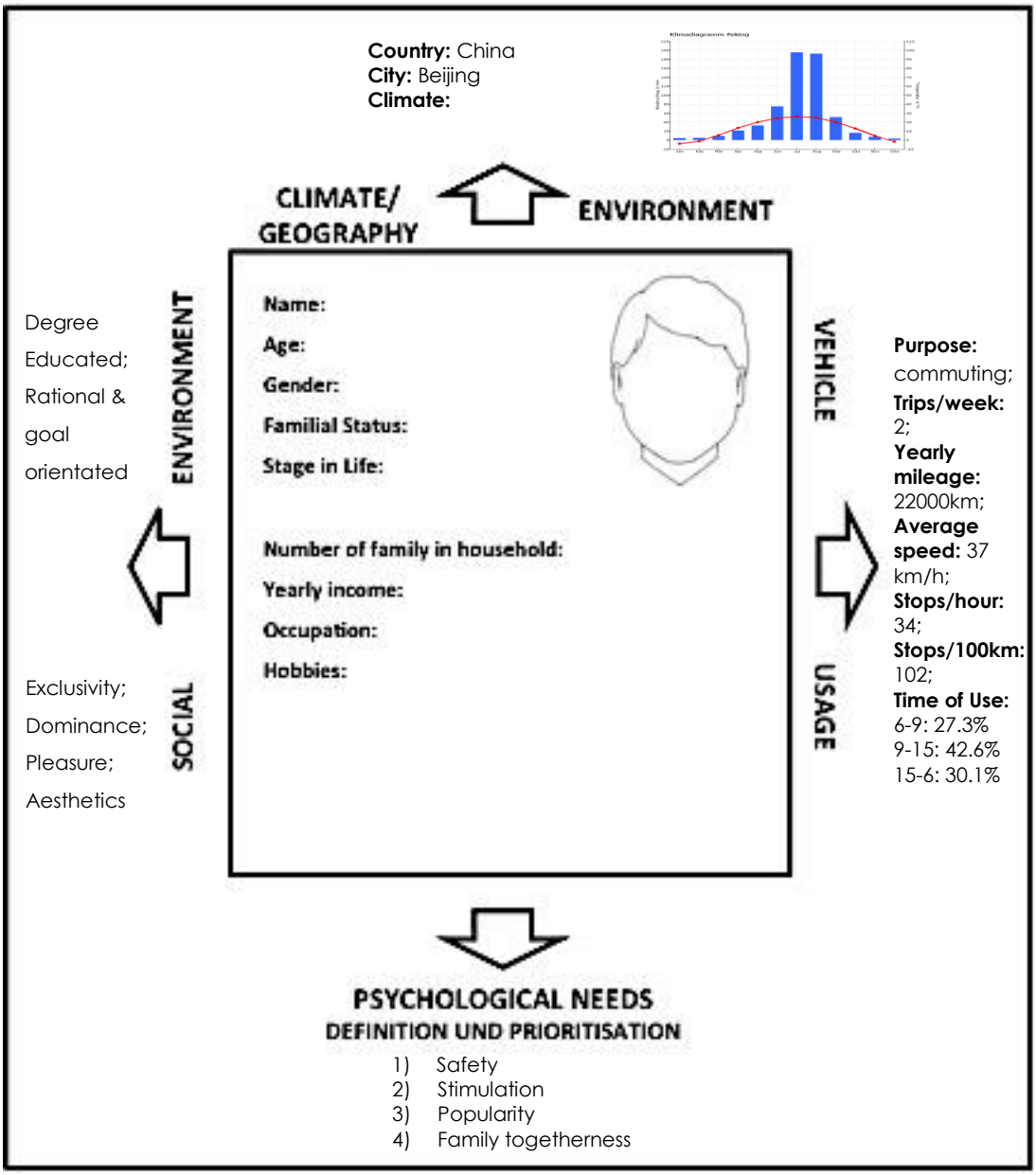


Figure 10 - Example of basic case firm persona

These personas were subsequently used in an experimental workshop process using storyboards in 2013. The individual personas were used to tell a story of their potential usage of a vehicle in order to engage engineers with the needs of their customers, and to help them develop customer design requirements. Initial analysis of the interaction of the engineers with the personas and storyboards conducted in 2013 was found to be generally positive, although reservations were held with regards to the non-technical nature of the approach (Gebauer, 2013). Furthermore, Gebauer (2013) found that

once the engineers had been able to identify technical requirements that could be associated with individual personas, they were more comfortable discussing the needs of the personas amongst themselves.

However, these initial analyses were quite limited in their conclusions and did not seek to include non-engineering staff from the firm in the persona and storyboard discussion. The process and findings outlined in this subsection represent the preliminary UCD-based actions taken by the firm in the lead-up to the commencement of the research.

6.3.2 Relation to the research

In attempting to evaluate the best way forward in fostering user focused thinking within the engineering design process, one individual engineer enlisted the assistance of the master student. The master student was able to act as a catalyst to help facilitate discussion of UCD (in the form of Personas) with departmental engineers. Furthermore, as the master student was not a direct employee of the firm, they were able to take an objective position concerning the opportunities and challenges for UCD implementation that became apparent in these discussions. This objectivity also provided the means for the proposition of options to be implemented on a larger, firm-wide scale to address the desire for a mind change in the firm towards user orientated vehicle development.

6.4 Summary

Section 6 outlined the background of the case study firm with whom the research was conducted. The history of the company and its vehicle development practices were explored. The current transition of the firm towards a new, customer-orientated business model was detailed, with the context of potential barriers and opportunities being given in terms of the mentality and culture within the company. Finally, the initial investigative steps regarding the implementation of UCD at

the firm were presented, providing the prologue to the involvement of the research and the basis for the involvement of the case study firm.

7.0 Research Design and Methodology

7.1 Introduction

The following chapter outlines the research methodology undertaken to form the core of this work. The objectives of this research are:

- To understand the key barriers and concerns pertaining to the implementation of a user centred design tool such as personas within engineering departments.
- To assess the most appropriate strategy for successful implementation of personas within the engineering development process of an automotive manufacturing firm.

In an attempt to achieve these objectives, the researcher sought to observe and comprehend the response of the case firm to the proposal to integrate user centred design within the engineering development process. Two methods of data collection were used to facilitate this process: 10 qualitative interviews carried out at the firm over the course of a week in December 2013, and a reflective journal documented during 6 months of full-time work with the firm in 2012, subsequent email and Skype project discussions over the course of 2012-2013 and during the week of interviews in December 2013. Thematic analysis was applied to the captured data to look for recurring patterns, which identified barriers and concerns that needed to be addressed for the firm to effectively engage in user centred engineering.

7.2 Approach to Research

The research resulting from interaction with the case study firm aims to determine the challenges needed to be overcome by the firm's engineers to adopt a user centred approach to engineering, and seeks to establish the opportunities available to facilitate this. Framing UCD and Personas around its applicability and usefulness to engineering departments will be key to collecting critical feedback

from participants. Appropriately communicating these user-focused concepts is vital to ensuring effective engagement with the engineers who have a history of resisting what they see as 'designer thinking'.

7.2.1 Action Research

As a result of the pre-existent inquiry begun in 2012 by the quality management firm engineer of bringing UCD thinking into engineering departments, the researcher adopted an action research approach to their investigation. This inquiry sought to target all stages of the vehicle design and development process, with a specific focus on the 'analyse', 'engineer' and 'design' stages (see Figure 9), in order to improve total vehicle quality.

Defined as an inquiry process that balances the need to solve a given problem with research to identify, understand and address the underlying cause of the problem (Reason & Bradbury, 2007), it was believed that action research would allow the researcher to compliment the actions of the firm's engineer through direct participation in the issue. This is supported by Brydon-Miller, Greenwood & Maguire (2003) who posit that action research provides a mutually beneficial outcome for project participants and the researcher through the direct contribution of the researcher to the project work as part of the process.

Such an approach places moves away from traditional, solely theoretical research, by providing a project solution or service outcome to a specific organization or individual, in addition to adding to existing academic knowledge on the focus area of the project (Georges & Romme 2004). This action research approach to the attempted solution of the research problem highlights the importance of the application of solutions, especially in technological fields (Kock 2013), and complements the engineering background and perspective of the research.

7.3 Methods

The research methodology underlying this action research was underpinned by two methods of data collection. These two methods consisted of interviews and the keeping of a reflective journal. Figure 11 and the following sub-sections provide a detailed description of the chronological occurrence of these events and what they entailed.

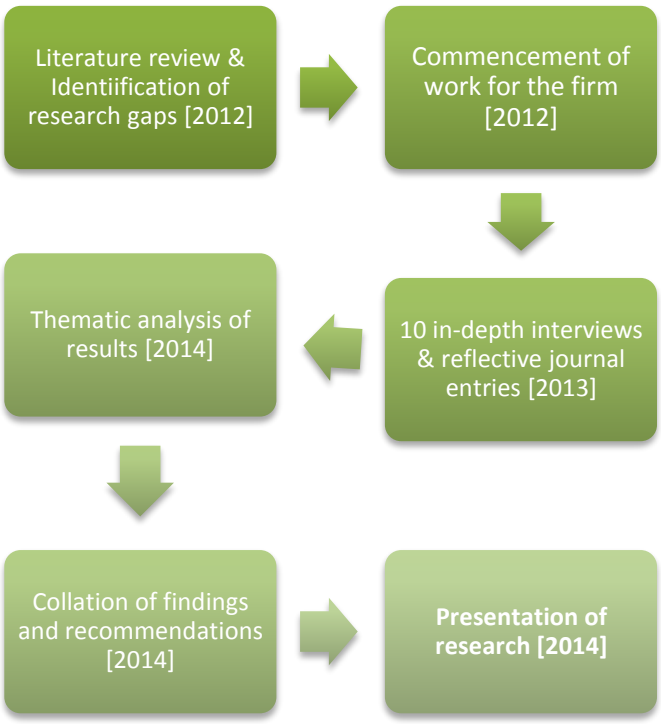


Figure 11 - Chronological representation of research methodology

7.3.1 Interviews

At the core of the research were 10 in-depth, semi-structured interviews lasting between 30 to 60 minutes. These interviews took place over the course of a week in December 2013, after the development of initial 'trial' personas in 2012 by the firm based engineer investigating the potential for UCD implementation.

Interview participants comprised a mix of engineers (3), senior engineers (5) and engineering management (2) operating within the 'analyse' and 'engineer' phases of the vehicle development process (see Figure 9). Participants were recruited by the firm based engineer

due to their previous involvement in the implementation of past new processes amongst the rest of the firms' engineers, and due to the key roles they would play in the rollout of UCD if it were to be implemented amongst engineering departments within the company. They were voluntarily recruited to participate. For greater depth and accuracy of the thematic analysis, the interviews were audio recorded and subsequently transcribed, an example of which is provided in Appendix C.

The interviews used semi-structured questions (see Appendix B) to guide the interview, focusing on the potential role playable by personas (as a representation of UCD) within the firm, and the perceived benefits and challenges that could arise from their implementation. The interviews used the trial personas as examples of the proposed user centred engineering methodology. Additional questions specific to the design and engineering process of vehicle development within the firm were used to better gauge participants' understanding and opinion of the potential for the implementation of personas in their work and the overall vehicle design process within the firm. The firm based engineer was also present to help facilitate conversation and address any language-issues that arose between the research student and the participants.

7.3.2 Reflective Journal

Often considered critical to the validity of qualitative studies such as this research (Ortlipp, 2008), a reflective journal represents a method in which to improve the transparency to the researcher and the reader of the decisions, values and thinking as they develop throughout the research process. This transparency is typically achieved through the documentation of thoughts and ideas on an ongoing basis throughout the research process, (RMIT Study and Learning Centre, 2012; Leitch & Day, 2000). Ranging from points of concern within the firm to be addressed by the research, to opportunities present that

could facilitate the development of solutions, the journal was used to better understand and reflect upon the time spent by the researcher at the firm and their interaction with the firm's employees.

Entries into the reflective journal provided a means to note and dissect verbal and non-verbal feedback and cues from employees to the present working environment within the firm, in addition to actions and discussions relating to the work of the research and UCD/personas. Journal reflections also included examination of the research project, including challenges and opportunities for gaining UCD buy-in, and general day-to-day issues occurring within the firm. Reflective journal entries were recorded whenever an interesting observation was experienced, organised by date of entry, and included specific details of the event and its context.

A combination of reflections during the full-time working period at the firm, in addition to throughout the research period resulted in a total of 64 pages of notational and observational data, used to better understand and reflect upon the interactions and behaviour of employees and the user-centred approach to processes. The entries help to increase the validity of the semi-structured interviews by providing an additional source of data from which to examine the firm. Furthermore, these observations contributed to the development of the thematic analysis through the provision of a foundation on which the themes identified from the interviews could be built. An example of such an entry is shown in Appendix D).

7.4 Analysis

Analysis of the data collected through the interviews and reflective journal took place through the application of the thematic analysis technique. Thematic analysis is used to look for patterns i.e. themes that reoccur throughout the collated data that are pertinent to a specific research question (Braun & Clarke, 2006; Daly, Kellehear & Gliksman, 1997). This process enables qualitative data to be converted

into themes, which can be used to answer the research questions posed as the basis of the process (Guest, MacQueen & Namey, 2012). Such functionality has resulted in the popularity of the approach amongst qualitative researchers (Guest, MacQueen & Namey, 2012) and its selection for use in this research. Figure 12 details the approach undertaken when applying thematic analysis to the research data.

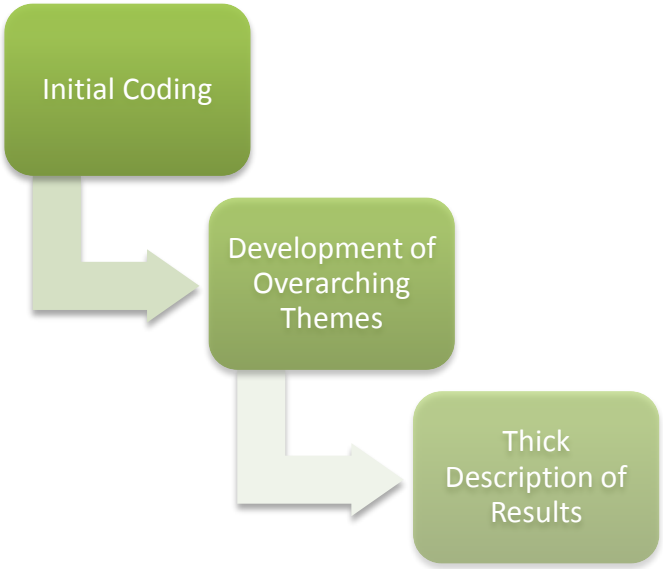


Figure 12 - Thematic analysis process

As the first step in the process, 'initial codes' are generated as the researcher sifts through the collated data and assigns codes to reoccurring patterns that occur within the transcripts (Braun & Clarke, 2006). The coding of the data serves to reduce the transcripts into a set of manageable categories, allowing for more efficient analysis of the data and inferences regarding its potential meaning and impact on the original research questions (Braun & Clarke, 2006). Twenty initial codes were generated based on initial readings of the interview transcripts and reflective journal entries, and are described in Table 3.

Table 3 - Thematic analysis coding scheme

	Code	Description	Example Quote
[A]	Institutionalisation	Comments on barriers to UCD due to existing company operations.	"We ask ourselves here in the E-area: How do we do this? We don't ask ourselves 'why' anymore"
[B]	Financial	Comments on barriers to UCD due to financial targets of the firm	"Also the profit is an argument, which is not in this paper here. So we can make it very, very helpful for the customer, and we will not make a profit with it"
[C]	Time	Concerns regarding time limitations impeding adoption of UCD	"The typical thing is, "oh, that's additional work for us, and we have no time to do additional work" because time is very important"
[D]	Workload	Comments relating to barriers to UCD formed by high individual workloads	"Because they simply don't have the time, they have more projects, they never have a specific time to dedicate to one project"
[E]	Customer awareness	Comments and concerns regarding the level of customer awareness within the firm	"Yes, testing department…and they do a lot of kilometres to test the car and to see if there is something…and they look with a customer view"
[F]	Designer-Engineer disconnect	Comments and concerns regarding the relationship between designers and engineers in the development process	"The engineers are working in between technical people from outside, so EK and EI and so on, and the designer, so we translate and transfer all requirements between those parties"
[G]	Status quo	Comments regarding the current day-to-day process involved in vehicle design and development	"To structure the requirements to look to the competitor, the competitors, and then you develop your contact, and then you make a list, which concept fits best to your requirements"
[H]	Implementation	Comments regarding the potential implementation of personas in the existing development process	"we have Personas…as an additional input for that, and we are…. we plan to make..for each team half a day training, to get that in…that additional thing…maybe not every component needs that customer profile. And I think that would be the introduce of these Personas in this whole thing"
[I]	Responsibility	References to individuals and departments responsible for the development process and potentially for	"So if such a method were to be applied, then you'd need a specific department, that works solely on this, or you would need specific 'method experts'."

		personas	
[J]	Timeframe	Comments referring to when in the developmental timeline personas should be integrated	"But I think there is a good aspect there, and I think we should integrated the customer needs earlier in the development process"
[K]	Acceptance	Any reference to individual or companywide perception/acceptance of personas and UCD	"I would happily apply such things and I try to bring these things into use in the department. I think the acceptance is also there with the others."
[L]	Needs	Comments concerning individuals' perceived needs to successfully carry out the vehicle development process	"this is the main problem for me and the main point where we can change things. Essentially the two things that you've already mentioned: Do people really need this? Do we have gaps?"
[M]	Customer insight	Potential positive outcomes that could be achieved using personas	"It's really helpful to know who, or what's important opinion from the customer"
[N]	Design	References to the impact of designers and design thinking on existing development process strategy	"So if a designer has an idea, it is our job to ask: how can we implement this? That is our job. Our job is not to say: That won't work, that is too difficult."
[O]	Engineering	References to the impact of engineers and the engineering process on company strategy	"The engineers are in the…'battle of the many objectives', they have to weight, to time, time pressure is there, costs and so-on, and they have to decide what's…what they will offer as a solution"
[P]	Value	Comments regarding the perceived value for using personas and UCD	"There where we have added value, I can simply isolate it and say: see, we have done it like this and this is what we achieved. If someone now says, I have here a customer profile and I have here my Personas and there are like this...then that would be quite interesting."
[Q]	Quality	References to the underlying need for high quality vehicles as the final outcome	"They all have financial constraints, and then time constraints, and then of course must the quality be of an acceptable standard"
[R]	Personas	Any comments or concerns relating to the potential results of implementing personas within the design and development process	"These Personas are naturally a great application to see, that the final customer would really want this, and not just the board (managers) but really the final customer, that there are people outside the company on the

			street that want it“
[S]	Tangible	The physical outcomes that could result from using personas and UCD	“It is helpful if you do it to get a really transparent view of the customer and then you have good decisions, and therefore you save time.”
[T]	Understanding	Comments relating to understanding of customers as a result of personas	“But for different and especially for new concepts, where we didn’t know what we are doing, I think it would be very very helpful to start more controlled, and to have the customer more in the focus”

Following the initial coding of the data, these codes were then compared to one another and consolidated into specific topic areas known as themes (Braun & Clarke, 2006). Four themes were initially generated under the title of ‘categories’ (as shown in Appendix F), and included: ‘barriers’, ‘process’, ‘strategy’ and ‘outcomes’. These themes represent the key meaning or understanding generated from the combined codes. That is, what aspects of the data are being captured by these patterns, and what is interesting about them. These categories are subsequently analysed with regards to how they support or address the theoretical perspective of the research (Braun & Clarke, 2006). This leads to further consolidation of the categories into overarching themes that provide the most meaningful understanding of the data collected from the research.

The overarching themes are presented as a ‘thick description’ of the results (as shown in Table 4 in Section 8.0) (Braun & Clarke, 2006). That is, the overarching themes are used to provide an understanding of the implications of the research question, but are grounded in the underlying behaviour of the participants and the contextual environment in which they are operating (Ponterotto, 2006).

An example of such an overarching theme is that of ‘institutionalised behaviour and thinking contributing to company inertia’ resulting from comments in the data that implied the existence of barriers in the firm

to the adoption of new methods or approaches. Transcripts were the main source of such data, as exemplified by one participant who was categorised into these theme due to their comment that "the process is easy when you draw it on the green table: everybody has the same interest, the best for the car. In real life, this is a process that takes months or years and with a lot of friction, to create the best solution. And so it's a daily fight and the result often is driven by… or will be won by the people who are stronger, or more convincing".

In seeking to complete the thematic analysis, a combination of TAMS Analyzer and Microsoft Excel software was used. TAMS Analyzer (Weinstein, 2014) is an open source qualitative research tool that facilitated the identification of themes from the collated interview and reflective journal data through a simplified means of coding the text (see Apendix E) using specific codes, as outlined previously in Table 3 below. These codes were then exported to Microsoft Excel for subsequent analysis in terms of the quantity and relational groupings of the codes (see Appendix F). This served as a straightforward means to carry out the thematic analysis of the data, and allowed for the researcher to easily return to the data for further analysis when themes were found to be incomplete.

7.5 Strengths and Limitations

7.5.1 Action Research

In engaging in the use of action research as the foundation of the research methodology, the strengths and limitations of this approach must both be acknowledged and addressed. Action research was in large part selected due to its suitability for use within the confines of the case study firm and its ongoing investigation into persona implementation. This is supported by Suhonen (2009) and Karim (2000) who highlight the ability for action research to allow the researcher to become involved in the project being analysed and to effectively contribute to its success. Furthermore, this approach helps to "narrow

the gap between theoretical and practical thinking" (Suhonen, 2009). This helps to ensure the research effectively contributes to both industry and academia.

However, in spite of the potential for positive outcomes to be generated through action research, the qualitative nature of the approach has drawn criticism in some circles. More specifically, Koch et al. (1997) and McDonnell (1998) argue that the findings of action research cannot be generalised beyond the context of the action research project. Similarly, Koch (2004) and Ellis & Crookes (1998) are wary of the time consuming nature of action research projects. Finally, Suhonen (2009) and Sandretto (2007) raise the issue of the potential for researcher bias both in the data collection phase through potentially marginalising certain participants' opinions, and in the analysis of the data and interpretation of the findings.

With respect to the first limitation regarding the generalisability of action research findings, Costello (2007) argues that the action research may not strive for external generalisability and "therefore it is unwarranted to criticise a piece of research in terms of its lack of generalizability when this is neither a stated goal for the work being conducted, nor an explicit intention of the researcher that carries it out". This is echoed by Popplewell & Haymann (2012) who posit that "as long as a researcher can establish internal generalizability – they can repeat their research findings within the setting they are researching – this should be sufficient for ensuring the quality and rigor of Action Research". That is, as long as the findings of this research are confined to global automotive manufacturers, action research should be considered a viable means of investigation.

With regards to the potential for researcher bias, Mehra (2002) maintains that the act of qualitative research is in of itself biased from the onset. Mehra (2002) maintains that the act of setting up and structuring the research is in of itself bias, with the best way to address

this is for the research to acknowledge the context and assumptions made concerning the research data and findings. Similarly, Ellis & Crookes (1998) suggest the need for the findings to be evaluated by others (such as the participatory firm and external reviewers) to ensure the validity of the findings.

Finally, whilst the time consuming nature of action research is raised as a potential limitation, it is believed that the arguments of Suhonen (2009) and Karim (2000) regarding the ability for the research to provide both a tangible contribution to the success of an ongoing project and a more theoretical contribution are enough to justify this potentially lengthy research process.

7.5.2 Thematic Analysis

Similar to the overarching action research methodology, the use of thematic analysis as the data analysis approach for the research will also be examined with respect to its strengths and limitations. Thematic analysis was selected both for its well established suitably for examining large, mixed datasets i.e. interviews and reflective journal entries, and for its ability to expand the analysis beyond the immediate individual experiences captured through interviews (Guest, MacQueen & Namey, 2012). This approach allows for responses from individual participants to be examined together within the context of the case study in order to develop an overarching understanding of the issues and opportunities facing the research (Saldana, 2009). Furthermore, thematic analysis tends towards the production of results that are accessible to a wider audience (Braun & Clarke, 2006). That is, this method of analysis ensures results are pertinent and useful to the participants in the case study and not just the researcher.

However, this very flexibility and general applicability of thematic analysis has led to calls for careful consideration of its limitations. Guest, MacQueen & Namey (2012) voice reservations regarding the

reliability of conclusions drawn from thematic analysis of data, as the approach leaves the data open to interpretation by researchers when drawing conclusions. Similarly, Braun and Clarke (2006) suggest that this interpretability stems from the flexibility of thematic analysis, making it difficult for researchers to focus on a specific aspect of the data.

With respect to the issue of data interpretability raised by Guest, MacQueen & Namey (2012), a similar argument is made as to the potential for researcher bias in Section 7.5.1. That is, that the act of the qualitative analysis is in of itself biased due to the initial framing of the research around a specific hypothesis and research questions (Mehra, 2002). Mehra (2002) argues that the best way to address this for the research to acknowledge the context and assumptions made concerning the analysis of the data. Similarly, Ellis & Crookes (1998) suggest the need for the findings to be evaluated by others (such as the participatory firm and external reviewers) to ensure the validity of the findings.

Finally, it is argued that the researcher bias developed due to the establishment of a research framework helps to nullify concerns regarding the potential for "over analysis" of the data (Braun & Clarke, 2006) due to the flexibility of the thematic analysis approach. More specifically, it is argued that this concern is partially addressed by the tendency for researchers to interpret the data based on their own research frameworks (Guest, MacQueen & Namey, 2012; Mehra, 2002), which would in turn solve the over-flexibility and openness of data analysis by the approach as raised by Braun and Clarke (2006).

7.5.3 Interview Sample Size

The final key potential methodological limitation identified was the number of participants interviewed as part of the data collection phase. Given the relatively small group of interview participants, 10, it

was felt that a brief discussion, of the sufficiency of the insight provided by such a sample size would be adequate to understand the firm on a wider scale, was required.

In the context of qualitative interviews, many researchers (Onwuegbuzie & Leech, 2007; Dick, 207, 2004; Patton & Cochran, 2002) support the suitability of a smaller sample size for research focused on analysing the transcript texts rather than the individuals themselves who are being interviewed. Onwuegbuzie & Leech (2007) suggest that "sample sizes in qualitative research should not be too large that it is difficult to extract thick, rich data", whilst Dick (207, 2004) states that a small sample size of transcript texts, from "one text to several" can provided suitable data providing participants come from a different range of organisaitonal and personal contexts e.g. age, seniority, department, role etc. Similarly, Patton & Cochran (2002) argue that "one way of identifying how many people you need is to keep interviewing until, in analysis, nothing new comes from the data".

From the data collected from the 10 semi-structured interviews, and the complimentary reflective journal entries, it is argued that in the context of understanding UCD through a line of enquiry centred around engineer persona implementation, 10 interviews provides enough scope that nothing new comes from further interviews. Furthermore, by interviewing a varied range of participants, from senior management in the 'analyse' departments, to low-level engineers in the 'engineer' departments, suitably "thick" and "rich" data was able to be extracted with regards to the wider automotive engineering manufacturer as a whole.

7.6 Ethical Considerations

Due to the active use of volunteer participants in the collection of data for the research, ethical considerations were found to be of key importance to the research design. As per the Queensland University of Technology (QUT) guidelines concerning research involving the

interviewing of participants, a low risk ethical approval form was completed and submitted. This resulted in the granting of approval for the data collection phase of the research to commence by the QUT Research Ethics Committee (Ethics Number: 1300000492). On the basis of this submission, all interview participants were asked to sign a consent (as shown in Appendix G) form prior to the interview.

7.7 Summary

This Section detailed the design and methodology of the research process. The research adopted an action research approach within the case study firm. Ten qualitative, semi-structured interviews and a reflective journal were used as part of the approach in order to develop an understanding of the challenges and opportunities for the adoption of UCD within the vehicle design process, from the perspective of the firm's employees. Due to the qualitative nature of the collected data, thematic analysis was selected as the method of data analysis. Thematic analysis was used to identify key themes from the data that represented the main challenges seen by staff to the implementation of a customer-orientated, UCD approach to vehicle development.

8.0 Results

8.1 Introduction

The following chapter presents the results of the research acquired through two methods of data collection, as outlined in the previous chapter. This included 10 semi-structured qualitative interviews and a reflective journal that was kept throughout the 24-month period of part time engagement with the firm. Reflecting the quest for answers to the underlying research, the results pertain to the main research question: *what are the key challenges and opportunities in seeking to successfully integrate user centred design through the adoption and implementation of personas in an automotive manufacturing company culture?* As such, the objective of this chapter is to delineate the challenges facing the adoption of a UCD approach within the firm. The following chapter will then capitalise on the understanding of these challenges to discuss the opportunities for addressing these challenges and implementing UCD within the vehicle development process.

To support the main results of the research, direct quotes from interview participants will be used to highlight the pertinence of the findings and inherent themes. Appendix E and Appendix F demonstrate how quotes from individual participant transcripts have been identified as matching particular response areas that subsequently reflect key thematic outcomes of the research. Whilst the direct quotes cited in the text are the sole means used here to elucidate the main results of the research, they do not represent the sole medium for the establishment of the findings and key research themes. These themes resulted from the combination of the two forms of data collection. The coding and subsequent analysis of the 10 interview transcripts was framed in the context of the case firm via understanding generated via ongoing commentary regarding

operations within the firm made in the reflective journal. This contributed to the establishment of the following key themes.

The table below outlines the key findings of the thematic analysis. The themes are ranked relative to their comparative impact on the firm, from a firm-wide pertinence down to departmental or disciplinary impact. Following their tabulation in Table 4 below, the key challenges facing the adoption of UCD within the firm will be addressed in greater detail.

Table 4 - Overview of key thematic analysis results

Theme	Description	Analysis Indicator	Code
Institutionalised behaviour and thinking contributing to company inertia	The impact of the engineering-centric company culture restricted by traditional, hierarchical methods. Furthermore, the effects on the design and development process	Any sentiment that implies a barrier to the adoption of new methods or approaches within the company as a whole.	[A], [B], [C], [G], [O], [P], [Q]
Design and development decision making concentrated amongst management	The influence of management in the decision making process due to the concentration of authority within firm management	Any sentiment that implies the influence of individual managers or management hierarchy in the vehicle development process.	[H], [I]
Engineering design and development driven by technical requirements and disconnected engineers	The challenges in establishing a user centred engineering approach to vehicle development in a traditionally technology driven environment. Furthermore, finding added value opportunities for UCD from an engineers' perspective.	Any sentiment that implies the involvement of engineers within the design and development process or their disconnect with the customer. Also, references to issues and opportunities regarding previous adoption of new approaches by firm engineers.	[D], [E], [F], [L], [N], [S]

8.2 Accelerating company inertia from institutionalisation

An underlying theme that was found to permeate all aspects of the company and its culture was the inertia and difficulty in achieving any significant change within the firm. That is, the institutionalised culture, operations and thinking manifested in day-to-day activity that leads to inertia and potential barriers to change. From the perspective of the researcher, this represents the fundamental challenge for the adoption of a UCD approach within the firm, due to its impact on all aspects of the firm. This result will be broken down into three areas contributing to the inertia: company culture, operations and thinking. These results will then be linked together to outline potential areas of opportunity to be capitalised upon, as detailed in Section 1.0.

8.2.1 Company culture

In the context of this research, company culture is defined as the set of shared mental assumptions that guide interpretation and action in organisations by defining appropriate behaviour for various situations (Ravasi & Schultz, 2006). As an industry leading global automotive manufacturing, these mental assumptions focused on the need for technical excellence and quality. This observation stemmed from the technical origins and underlying operations of the firm, and was highlighted by participant commentary about vehicle development operations: "*what I have learnt and experienced by now is that it is still very, very target orientated*". Further reinforcing this notion of technical targets was a participant's description of the general aim of all firm stakeholders, "*everybody has the same interest, the best for the car*".

Such focus on the product, rather than the end user of the car, provides a telling suggestion of where the general focus within the firm lies. When the placement of the end user within this company worldview was questioned, one engineer lamented "*we have lots to*

do with developing the character of the vehicles, but nothing regarding solutions for customers". Whilst at an individual level this seems to indicate an awareness of potential limitations raised by the technical culture within the firm, at a firm-wide level there appeared to be barriers to such understanding.

These barriers arise from this very target orientated nature, with participants raising concerns about the lack of time availability to successfully complete new tasks. "*We simply don't have the time, we have more projects, we never have a specific time to dedicate to one project*". Such resistance to new projects due to a perceived lack of time is further compounded by the flow-on-effect of this time pressure. This flow-on-effect is an amplification of the technical, target orientated company culture, with the customer facing ongoing marginalisation from day-to-day activities (as further detailed in Section 8.3). As one participant put it, "*we ask ourselves here: How do we do this? We don't ask ourselves 'why' anymore*".

8.2.2 Company operations

This culture within the company is further reinforced and institutionalised through the day-to-day operations within the firm. As is hardly surprising in such a large, global firm, operations are vertically integrated, with much of the decision making and target setting process passed down from above (as examined in Section 8.3). Furthermore, lengthy development requirements for a new vehicle, "*starting very early, 70 months in advance*", have led to extreme specialisation within different departments in order to meet the rigid pre-set deadlines. This departmentalisation is evident in each vehicle project, with one participant commenting, "*we have 35 modules (departmental teams) or something like that for the complete car*".

Such departmentalisation and specialisation has resulted in very homogeneous, mono-disciplinary departments, with "*the targets of*

the different parties are very different, so everybody has a different target and focus". With different targets and foci between departments working on the same project, the firm has adopted a unique approach to communication between vehicle development engineers and designers known as the "*lawyer of the designer*" *department*. That is, following the target orientated results culture of the firm, such a go-between department seeks to "*translate and transfer all requirements between those parties*" in order to "*push the people to solve their conflicts*".

Lack of understanding and communication between the different project departments is hardly surprising. Their homogeneity and isolation from one another is broken only through meetings of department heads, or through non-work-related discussions of individuals in the foyers, canteens and coffee stations present throughout the firm. As one engineer described "*a lot of ideas come from our designers. And the designers are again socially different (from the developers), visit art schools etc., they have a totally different source of inspiration that I don't understand. From there come many ideas, not from us.*" Given the integral role of engineers and designers in the development process, facilitating understanding between these two parties and overcoming the isolation between their departments represents a significant opportunity for furthering design centred approaches such as UCD. However, as one engineer interacting with designers commented, overcoming such departmentalisation in company operations "*is not easy. This is where clashes happen, interests are conflicting. There are big conflicts*".

8.2.3 Company thinking

The institutionalised inertia towards the adoption of new approaches is not just present at a firm-wide level, but has come to condition thinking at an individual level. Especially within engineering departments, this thinking has come to be reflected by "*financial*

constraints, and then time constraints, and then of course must the quality be of an acceptable standard". When questioned on the potential for the adoption of new approaches such as UCD by engineers, one participant raised concerns linked to the fundamental technical target orientation of the firm, "*what I think is that we are too limited, too narrow focused, We are not flexible enough*".

This inflexibility is not to suggest an underlying resistance to the idea of UCD represented by the proposition of the introduction of personas. As many participants reflected, "*these personas are naturally a great application to see, that the final customer would really want this, and not just the board but really the final customer, that there are people outside the company on the street that want it*". However, when asked about challenges facing their implementation, concerns were raised that "*the typical thing is, 'oh, that's additional work for us, and we have no time to do additional work' because time is very important. We are too slow and then we can't do additional work.*"

Such contradictory views to personas seem to validate the inertia to change generated from the time-pressured, results focused mentality underlying all operations and decisions within the firm. As one senior engineer stated with regards to the adoption of new design and development methods within the firm, "*it is the peoples' acceptance, and we can teach them as much as we want, even if they want to do it, they still don't have the time.*"

From a firm-wide perspective, this institutionalised inertia towards the adoption of new approaches such as user centred design stems from the widespread acceptance of these cultural, operational and thought-based barriers. One participant summarises the challenge as, "*I think something, we have to do something like mind-change; but to get this opinion or mind change, is the hard part*".

8.3 Managing the engineering process

At an institutional level, this mind change is key to transitioning towards the customer-orientated approach touched upon in Section 4.0 and the basis for this research. However, to get this mind change, the decision making process at the heart of the vehicle development process must first be addressed. The second observed challenge to UCD adoption was managing the managers and their engineering decisions. That is, the dependence of all development decisions ultimately residing with departmental management. Furthering the need to include, if not focus on, departmental managers in discussions pertaining to the implementation of personas is the understanding of their sheer influence over design process choices and the subsequent tasks undertaken by the engineers under their command.

One participant discussing the engineering decision making process reflects: *"we place a lot of time and effort into a design, but only do it the first time, because one of us (from the department) wants it that way. And the person that wants it is not the customer, but the department manager, who says, we have to include these options. And the reason for this, often not even they know, because someone said so*". Furthermore, this top-down approach to design results in engineers who are often not engaged in the reasoning behind the work they are completing. Participant 3 elaborates: *"At the moment everything comes from management. They are specifying everything. Of course, someone else (non-manager) maybe thinks a little bit about it, also about the bigger picture, but that is totally voluntary. I would say that everything is already specified in advance for the engineers"*.

Emerging as the underlying institutional barrier, 'technical requirements' represent the focus of the automotive manufacturer on developing their vehicles to meet a certain list of pre-determined quantitative specifications (e.g. top speed, acceleration, mileage,

torque, horsepower etc.). Whilst such detailed, data driven specifications are vital in completing the necessary calculations for engineering a vehicle, it is argued that the fixation of the engineering design process on technical requirements is inherently institutional. When discussing the development process, one engineer notes that: "*the department manager is always a part owner of the project, they delegate the work and say: you are now doing this and implement these technical specifications*". This suggests that the engineers have little say over the choice of a technology-centred design process which stems not from engineers themselves but rather from higher-up and/or elsewhere in the firm. Similarly, Participant 1 elaborates on the design process implemented by the automotive engineers where "*…with the requirements look to the competitor, the competitors, and then you develop your concept, and then you make a list, which concept fits best to your technical requirements*…", highlighting the dependence of all design decisions on their need to fit the predefined technical requirements.

However, this managerial behaviour is of itself a result of the institutionalisation within the firm. Managers are responsible for achieving the aims and targets set down for a project, which are in turn based upon company operational guidelines. This responsibility to meet targets further reinforces the technology driven nature of their decisions. As one departmental manager suggested about firm management in general, "*then they have to say, ok that's my costs, that's my weights, and I have to be ready there. Time, costs, quality, function, weight and emissions*". The operational goals set out by management are then enforced by 'method experts' within each department.

These method experts are responsible for overseeing the implementation of the vehicle development approach on behalf of departmental managers. In assessing the potential for getting

managers on board with the use of UCD it quickly became apparent that engaging with the method experts would be crucial. Initial discussions of the potential for using personas amongst method experts elicited comments that "*in general the acceptance from the method experts is definitely there*", suggested a likely point of engagement for adding UCD thinking to the decision making process.

8.4 Customerising engineering thinking

This institutionalisation of engineering design as a hierarchically dominated, top-down, decision-making process has significant flow on effects. As the basis of the success of any technology dependent project, engineers within the firm are heavily influenced regarding the way they think about the individuals who will purchase and use the vehicles they are developing. In short, they don't. One participant bemoans the lack of comprehension as for whom the vehicles are being manufactured, "*there is no person behind this, that is tangible, that people can relate to and understand why they want this feature*". This lack of awareness of the user is prevalent throughout engineering teams, where the engineering "*team leader has no influence over whether the concept is relevant to real customers, because they are only working on small things*" and this stems back to the apparent lack of input the engineers have in the overall design process.

As the basis of the success of any technology dependent project, the need for a shift in the thinking of the automotive manufacturer's engineers was also seen to be vital in any proposed shift towards a customer centric approach to vehicle development. "*We don't know…then the discussion usually ends there, because we don't know, nobody can answer for what reason did the customer come to the dealership.*" This institutionalised removal of the engineers from the design decision-making process has in of itself created the issue where the engineers themselves "*don't see, that there is a customer somewhere that wants it*", that wants their vehicles. The lack of

customer awareness in the design has historically combined with the departmentalism within the firm to result in designs of individual vehicle components that "*made sense to the engineers within the firm at the time, but are not at all intuitive or easy to use*".

This is not to say that the implementation of personas, and through them user centred design, faces no barriers directly from the engineers. As one engineer put it "*there are many professionals that have been here for ages doing this and they always say: 'I've always done it like this, I can't do it any other way. I always do it like this. Now comes something new, how is this supposed to be better'*". However, such apparent resistance to change appears to stem directly from the disconnect between the engineers and the users for whom they are designing, and from a lack of understanding. As put by a senior engineer regarding highlighting the usefulness of personas, "*my opinion to increase the acceptance and to develop enthusiasm for this topic in the department. That people don't just blindly develop a product, but instead think: ok, can I optimise this? Maybe this is handicapped, maybe I can make this better.*" At heart this ties into the underlying culture of technical excellence expressed by the majority of engineers within the firm..

Additionally, discussion with designers within the firm highlighted the importance of communication towards engineers, with design tools initially rejected out of hand by engineers for being "*too warm and fuzzy*". It was related that engineers and technical decision makers would often "switch-off and become disagreeable" when terminology such as storyboards and customer heuristics were used. Further investigation led to the discovery that engineers became more accepting of design led projects when designers communicated their ideas using terminology and information more readily understood by the technologically minded engineers. However, issues were also raised concerning engineers' understanding of design approaches,

even when communicated effectively, with engineer and managers alike found to be saying "we've been doing that for years" in spite of this not being the case.

It has been suggested that such barriers could be challenged by highlighting the tangibility of the user-customer to engineers: "*If someone now says, I have here a customer profile and I have here my personas and they are like this...then that would be quite interesting, because it is a completely different aspect, the customer is completely different, sort-of. And alone that would help, because developers often forget the customer*". This potential for adoption is also evinced by the current issues facing engineers, as "*it is really important for the developer to know the real customer, and the real customer opinion Just to see the US market, European market, China market, and then he gets a problem. Maybe these three markets are different, and know he has to design a component which fits for all three markets. And that's a problem.*" Furthermore, the underlying time pressure affecting the engineers like all firm employees was also found to be surmountable using a persona and UCD approach, as "*it is helpful if you do it to get a really transparent view of the customer and then you have good decisions, and therefore you save time*".

Such a need to understand the existence and importance of real users by the engineers developing the vehicles, and ensuring this thinking is at the core of engineering design is stressed by Ward, Runcie & Morris (2009) and Bucolo & Matthews (2011). They stress that an understanding of the user is of tantamount importance for ensuring automotive manufacturers have the knowledge and flexibility to integrate potentially changing customer requirements, and thus remain competitive in the global automotive market. This suggests the need for further education of engineers if UCD is to be integrated throughout the vehicle design and development process.

8.5 The firm as personas

Further to the key observations rising from the thematic analysis of the research data, it was also found that key personas arose from the research. These personas were found to be representative of the key stakeholders dealt with through the research project: managers, designers, and engineers. They have been developed in order to provide a better understanding of the types of individuals being addressed by the opportunities for action proposed in Section 9.0, and their needs that should be met in order to achieve buy-in for the implementation of UCD within the firm's development process.

8.5.1 Engineering management

Andreas is 53 years old and works as an engineering department manager within the case study firm, making key decisions concerning the vehicle design and development process. He has worked at the firm for 20 years, progressing from a junior engineering position to his current management position. Andreas' loyalty to the brand manifests itself through his outspokenness to everyone he meets about the high quality of their vehicles, and his ownership of a high-end vehicle manufactured by the firm.

During his time with the company, Andreas has seen many vehicle development approaches come and go. However, a technological focus has underpinned all design work during this period, and he has become accustomed to this approach, which has resulted in the firms' status as a leading luxury vehicle manufacturer. He has heard about the recent push towards a more customer-orientated business model within the firm, but is unsure as to whether this is just a passing fad that will not upset the status quo of the past 20 years.

Andreas is ultimately concerned with maintaining the reputation of the brand, and is always on the lookout for opportunities to minimise costs, increase efficiency and maintain the high quality of his products. To this end he is looking for innovative approaches to vehicle design, as

he understands the "bigger picture" of the firm and the current competitiveness of the automotive market. However, he has seen the firm grow and succeed based on traditional engineering principles, and does not want to risk the success of the brand by making big changes to his decision making process. When combined with his engineering background, this results in a very conservative outlook towards design-led approaches such as UCD, which he does not fully understand, although he appreciates the advantages that such methods could bring to the firm.

8.5.2 The average engineer

Georg is 41 years old and works as an engineer within the drivetrain engineering department, completing technical design calculations for key vehicle components. He has worked at the firm for 10 years, and has been responsible for completing engineering calculations in a variety of engineering departments around the firm. Georg is very loyal to the firm, and manifests this loyalty through a low-end company vehicle, which is all he can afford, and through a pride in the quality of the vehicles that he helps to build.

During his time at the firm, Georg has become accustomed to receiving instructions from management and carrying out his assigned tasks to a high standard. He rarely questions why he is completing a given task, but assumes that there is a valid reason for every task that he is assigned by management. This is predominantly due to his pride in the technical excellence of the firm that has allowed the firm to become a global industry leader. He has recently heard of the push towards a more customer-orientated approach within the firm, but does not fully understand what this means. Nor does he have the time to worry about it given the large number of project tasks he is responsible for completing to deadline.

Georg wants the firm to continue to succeed, and has been quite capable of adapting to new approaches handed down by management in the past. However, given the high level of time pressure he is under regarding his current tasks and his focus solely on the technical aspects of vehicle design, Georg is reluctant to take-on additional work, which is what he sees UCD to be. Furthermore, given the history of success at the firm, Georg does not fully appreciate the challenges facing the firm and its subsequent push for new, innovative approaches to vehicle production such as shifting to a more customer-orientated stance.

8.5.3 The progressive engineer

Steffen is 32 years old and works as an engineer within the quality management department as a "method expert", able to guide fellow engineers in key engineering approaches. He is responsible for assessing the customer-feedback to the vehicles produced by the firm, and examining how design quality can be improved in future models. He has worked at the firm for the past 5 years, and whilst loyal to the brand, has become aware of weaknesses at the firm that are a result of its ongoing technical excellence and success.

Steffen is keenly aware of the challenges posed to the firm by this technical-centrism and by rival automotive manufacturers. This has resulted in his search for new ways to improve the ability of the firm's vehicle products to meet customer requirements and subsequently to maintain the perceived high level of quality of the firm's vehicles. However, research by Steffen into addressing these issues has resulted in frustration due to the institutionalised technical-requirements focus within the firm, and the chronic lack of time staff have for new projects.

Whilst Steffen is keen to experiment with new approaches to improve the outcomes of the design process, and understands the potential of

new ideas such as UCD, he is restricted by the need for a "step-by-step" approach to its implementation if it is to be culturally acceptable in the firm. Furthermore, he lacks seniority and decision making authority, requiring him to pitch any new ideas, such as a persona-driven UCD approach, to management if it is to be successfully implemented.

8.5.4 The designer

Wolfram is 34 years old and works as a product designer within the design studio, working with the product line departments on new vehicle designs. He has worked at the firm for 4 years, and has come to see the benefits of multidisciplinary design teams after working on experimental vehicle concept projects. However, Wolfram sees engineers and designers as quite separate in terms of their tasks, and he has become quite frustrated by the design limitations imposed by the firm due to its technical-requirements focus on vehicle design and development. Furthermore, he does not fully understand the technical design approach used by engineers within the firm.

In terms of adopting a customer-orientated approach such as UCD, Wolfram is highly familiar with the approach and uses its design tools on a regular basis as part of his project work. Furthermore, he is an effective storyteller who can convey the UCD concept to others. However, due to the dominant engineering culture within the firm, Wolfram is seen as an outsider by engineers, as they do not fully understand what his role in vehicle development is, and miscommunication between Wolfram and engineers has been known to arise due to the different "languages" spoken by designers and engineers at the firm.

8.5.5 Interaction of in-firm personas

Looking at the key stakeholders represented by the 4 aforementioned personas it is apparent that whilst they are all working towards to

successful production of a high-quality vehicle, they are each operating with their own pre-conceived focus, objectives and understandings. In the context of UCD uptake, only Wolfram the designer and Steffen the progressive engineer seem to truly understand the role it could truly play within the firm. However, neither of these stakeholders, who operate in the 'design' and 'analyse-engineer' phases respectively, have the authority to rollout such a concept framework by themselves. In contrast, engineering management like Andreas don't fully understand UCD, and despite their power to implement new frameworks (due to their operation across the spectrum of the design process from the 'define' stage through to the 'engineer' stage), are reluctant to move away from the existing technology driven approach. Finally, the average engineer Georg appears resistant to new concepts such as UCD, seeing them as additional work that only serves to make the majority, average engineers' lives harder within the large 'engineer' stage of vehicle design.

Thus, in spite of the existence of stakeholders like Wolfram and Steffen with positive views towards UCD implementation, technical staff are currently divorced from UCD processes and thinking, as it remains solely in the hands of the firm's designers.

8.6 Summary

This chapter has presented the key results that emerged from the data through 10 qualitative interviews and a reflective journal. The results represent the main challenges that face the implementation of a UCD approach in the firm. The results transitioned from the most high-level observations at the beginning of the chapter to the most low-level observations at the end.

The first theme identified the cultural and institutional inertia within the firm that acts as a barrier to the adoption of new ideas, such as UCD, due to limitations in existing firm behaviour and thinking. Supporting

this high-level theme was the mid-level theme that grew out of the concentration of design process decision-making in the hands of management. This theme outlined the challenge posed by managers to the adoption of UCD, and highlight the need to gain buy-in from managers if UCD is to be implemented within the existing vehicle design and development process. Finally, the research found that the institutionalised, technology driven requirements culture at the firm has resulted in engineers becoming disconnected from the customers for whom they are designing a vehicle. This theme discusses the challenge posed in gaining buy-in with firm engineers, who are trained to focus on achieving technical targets handed down by management.

The following section examines the opportunities for the firm to overcome these aforementioned challenges on the road to a UCD approach to vehicle development. These opportunities will aim to provide solutions on both a theoretical and commercial level, facilitating the continued firm-transition towards increased customer-orientation, whilst addressing the gaps outlined in the available UCD and automotive literature.

9.0 Discussion

9.1 Introduction

The key themes raised in the previous chapter highlight the underlying challenges that must be overcome for a global automotive manufacturer to transition to a user-focused design and development process. These challenges, as outlined in Figure 13, reflect the level of potential positive impact that could be had by UCD on the firm if they were overcome.

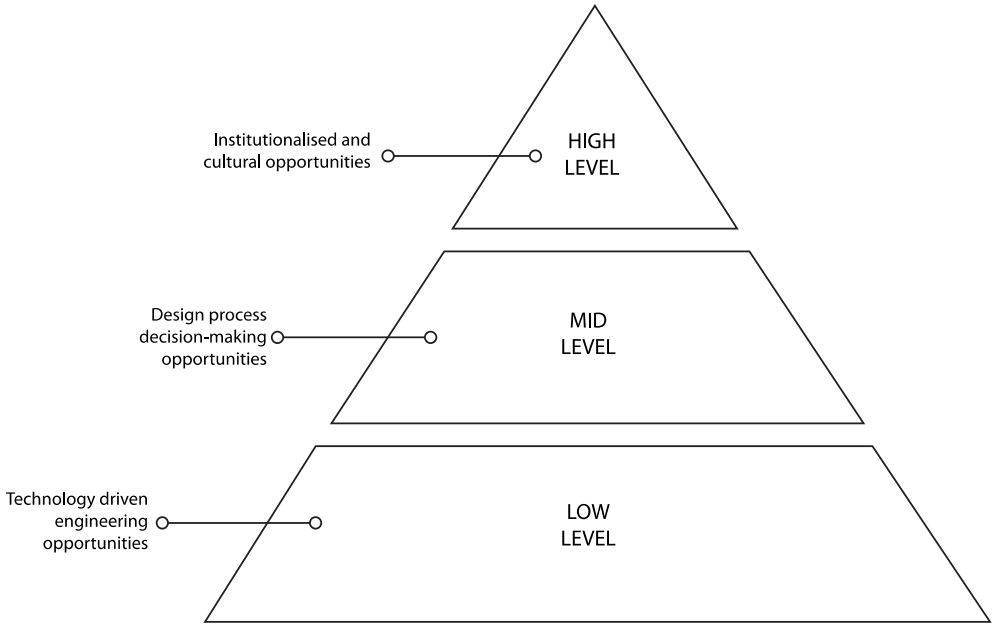


Figure 13 - Levels of Case firm challenges

The high level challenge represents the impact of the existing company culture on the improvement of the design and development process using UCD. This challenge affects all operations and departments within the company, and would require the most effort to overcome. However, an opportunity to address this high level challenge could also result in the largest potential impact of UCD within the firm.

Reflected by the influence of management in the decision making process due to the concentration of authority within firm management, the mid level challenge highlighted in Section 8.3

shows the direct impact of the technical company culture on the design and development process by management. This challenge is widespread, but predominantly affects the operations within the departments concerned with vehicle design and development. The opportunity to overcome this barrier to a customer centred focus in the decision making process could allow for a significant shift towards the implementation of customer needs and requirements in the vehicle development process through the uptake of UCD by management.

The final and lowest level challenge refers to the technically orientated focus of company engineers to vehicle design and development. This focus and understanding of what it means to design and develop a vehicle poses a foundational challenge to the adoption of UCD and through it a more user centred approach. That is, engineers are the foundation of the firm and its operations, so the opportunity to foster the implementation of UCD principles at the technical heart of design and development operations represents the fundamental, low-level challenge to be addressed by the research.

The following discussion chapter seeks to highlight the main opportunities identified from the challenges described in Section 8.0. Figure 14 below frames the proposed opportunities for the firm in the context of the level of the existing barriers, and will prove the basis for discussion concerning the future implementation of UCD within the firm.

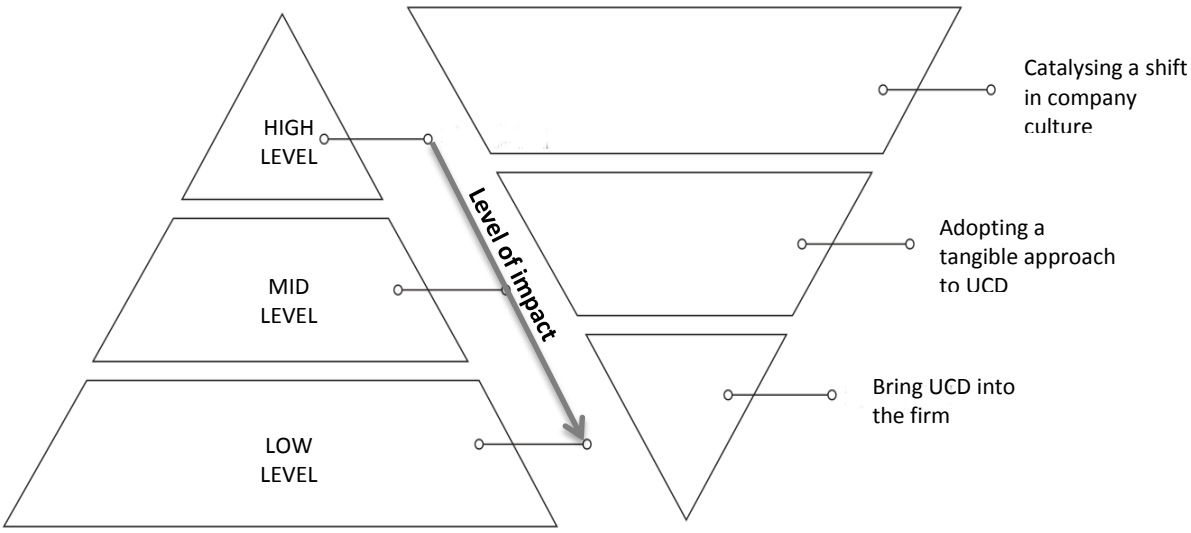


Figure 14 - Opportunities and impact levels for UCD

The pyramid of opportunities commences with that at the highest level and widest potential impact down to the lowest level, lowest impact opportunity (from a cultural shift down to individual engineering design mentalities). These opportunities will be discussed sequentially, in addition to the development of a framework which is proposed to combine these actions with existing firm methodology i.e. combining UCD and traditional vehicle design and development approaches. Furthermore, these opportunities will be discussed in the context of the 4 personas, characterised in Section 8.5, in order to allow the reader to better understand the nature of the key stakeholders in this process.

9.2 A shift in company culture

9.2.1 Catalysing the shift

The underlying point of investigation for the research was to examine the implementation of a new design approach, summarised by the main research question as: *What are the key challenges and opportunities in seeking to successfully integrate user centred design through the adoption and implementation of personas in an automotive manufacturing company culture?* In light of this it is rather fitting that the opportunity for the widest potential for impact in the case study firm looks to address the cultural challenge in the firm. That is, overcoming the existing institutionalised behaviour and thinking in

order to shift towards a more customer-orientated, UCD approach to vehicle development.

Review of the existing literature pointed to the fact that many firms were already looking to shift their business models and culture in order to remain competitive in the global industry (Accenture, 2010; Oliver Wyman Group, 2007; Tischler, 2004). However, the available literature focused on a shift by designers, for designers and design studios (Knobel et al., 2012; Tscheligi, 2012; Gellatly et al., 2010; Patton, 2009), rather than on firm-wide transitions towards customer-orientated approaches to vehicle design and development, namely through the adoption of UCD by the majority of development staff i.e. engineers.

The research attempted to address this gap in the literature, and found that similar research existed concerning the adoption of design methodology from a business perspective. Wrigley & Bucolo (2012) proposed the need for a "transitional engineer" to bridge the gap between design and business and allow for effective communication of ideas between the disciplines. They in turn built on the ideas of Norman (2010), who suggested the need for an intermediary to facilitate effective collaboration between the design and business stakeholders.

In a similar manner to the concept proposed by Wrigley & Bucolo (2012), the results of the research suggest that there is a need for someone similar to a transitional engineer to bridge another gap, that between design and engineering. A 'mid level' approach would be to approach departmental managers and key decision makers with the concept that UCD could be addressed by an intermediary translation team who would "translate the knowledge into practical realisations that the team (business) can then develop and deploy" (Wrigley & Bucolo, 2012). However, a translation into a business-context is unlikely to work on a firm-wide level that includes engineers. Given this restriction, a new breed of transitional engineer, a "designeer" is

proposed to function in all three worlds – design, business and engineering. They would comprise individuals familiar with company methodology concerning these fields (i.e. engineers, designers and marketers), and would facilitate the implementation of user centred methodologies, such as persona use, within the vehicle design processes of the automotive manufacturer.

The designeers would need to operate comfortably in these three fields, moving between departments and projects as needed to ensure the customer-orientated vision of future projects is effectively communicated to and implemented by all project stakeholders. This ability to communicate effectively to a variety of stakeholders highlights the need for the designeer to be able to understand and thus communicate the concepts from the perspective of engineers, designers and marketers. Further key skills required by designeers to successfully operate and implement UCD within the firm are similar to those proposed by Wrigley (2013) for a design innovation catalyst:

- Understanding of underlying business principles of the firm: not exclusively including strategy, new product development and organisation change;
- Ability to challenge the existing culture and operations of the firm;
- Capable of speaking authoritatively on the usage of UCD and its implementation in the existing vehicle development process;
- Ability to physically implement UCD tools and methods and subsequently generate results;
- Genuinely believes in the potential benefits for the firm of implementing UCD;
- Strongly desires to continually improve existing processes within the firm;

- Ability to engage with relevant stakeholders in the firm to obtain buy-in and transition individuals and departments to a UCD approach

This opportunity for using designeers as catalysts within automotive manufacturers to facilitate the company-wide adoption of UCD approaches was also supported by the research data. Individual responses at the case firm concerning the implementation of UCD suggested that "it seems to be a good time for this, because everyone is saying 'customer, customer, customer' first, quality, quality, we have to think about the customer", suggesting that methods of centring design projects on the customer were likely to be welcomed at this stage in the life of the business. Furthermore, the need for a specific team of individuals i.e. designeers to implement UCD was raised by managers personified by Andreas, who felt that "I would definitely moderate this. Yes, otherwise it would disappear somewhere into a drawer, and it is too quickly forgotten."

9.2.2 Framing the shift

This proposed concept of "designeering", whilst seemingly at odds with the traditional manufacturing approach separating engineers and designers, as seen at the case firm, could be crucial in ensuring the acceptance of the general engineering staff like Goerg. It would allow for a shift in the institutional mentality found at many large automotive manufacturers. As one case firm design engineer recounted:

"I think the most important thing is the acceptance, because people have to come to us, and tell us, and ask us 'could you please help us, we are developing this part, could you help us so we know what we have to look into', and people don't do that".

The implementation of "designeers" and the implementation of UCD in vehicle development would take place in the context of the

traditional automotive design framework (Figure 3) and the UCD framework (Figure 5). That is, it would build upon these approaches in order to re-connect engineers with designers via a customer-orientated vehicle design framework driven by designeers, as shown in Figure 15.

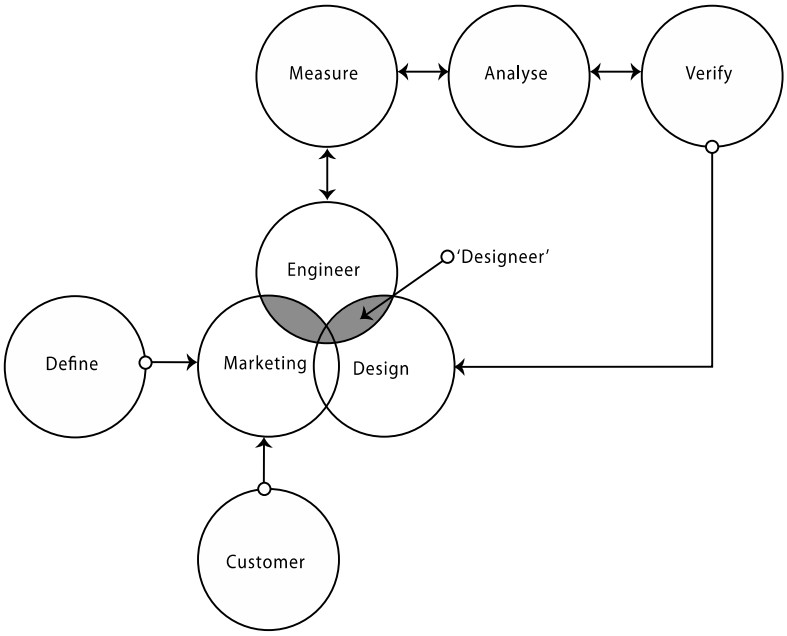


Figure 15 - New proposition for vehicle development process at the case firm

Designeers would be responsible for framing each stage of development in the context of customer needs and requirements as reflected by the Personas, and by focusing on the development of the vehicle's story in the initial project definition stage. Designeers would bring average engineers like Georg and progressive engineers like Steffen, together with designers like Wolfram and business-minded marketers to develop approaches for the 'engineer', 'design' and 'market' development stages that complimented one another. The facilitation of collaboration amongst different stakeholders would in turn result in a final product that reflected the needs of those for whom they are developing the vehicle. This process would also provide departmental managers like Andreas with a clear idea of the

accuracy of the vehicle design at different stages of development, and a method of verifying the product is suitably user-centric.

Opportunity 2 further develops this proposal by examining the opportunity for action that the designeers could undertake in order to establish UCD as a familiar and comfortable method for vehicle design and development within the firm.

9.3 Communicating a user centred approach to vehicle development

9.3.1 Managers are the key

A recurring theme documented during time with the case study firm was the importance and influence of managers in the vehicle design and development decision-making process. Given this importance, it is apparent that gaining the buy-in and acceptance of managers like Andreas regarding designeers, and in turn of a UCD approach, is vital to its success at a firm-wide level.

From a theoretical perspective this is supported by Gulliksen et al. (2003), who argue that acceptance of a UCD approach requires the presence of experts (i.e. designeers) to champion the concept to key decision makers. This is further supported by Papadakis, Lioukas & Chamgers (1998) and Midler & Navarre (2004), who reiterate the key role played by managers in the adoption of new approaches, and thus the importance of obtaining the acceptance of management towards designeers and UCD.

9.3.2 Opening the mid-level lock

Despite this positivity towards seeding a mid-level UCD mind change in managers using designeers, a question remains as to what action needs to be taken in order to facilitate their engagement with, and understanding of, a UCD approach. The action proposed by the research is the adaptation of the Osterwalder & Pigneur (2010) business model canvas to provide a tangible teaching model for

designeers to discuss and teach the application of UCD in the vehicle development process to engineers and engineering management.

Led by designeers, this user centred engineering canvas (see Figure 16) would be used as a key training tool in the existing methodology of the training centre at the firm known as the 'Experience World'. This training centre regularly takes engineers and engineering management from different departments around the firm and trains them in the latest vehicle design and development processes.

The similarity of the tool to the generic business model canvas was designed to ensure its familiarity to managers and key decision makers in automotive firms (as outlined in Section 2.3). It would be used to help engineering management understand the UCD-based requirements for developing a suitable vehicle solution. This objective of a 'vehicle solution' would be framed by a focus on user/customer requirements, with the process broken down into the individual process building blocks required to develop and then implement a user-centred vehicle design and development process.

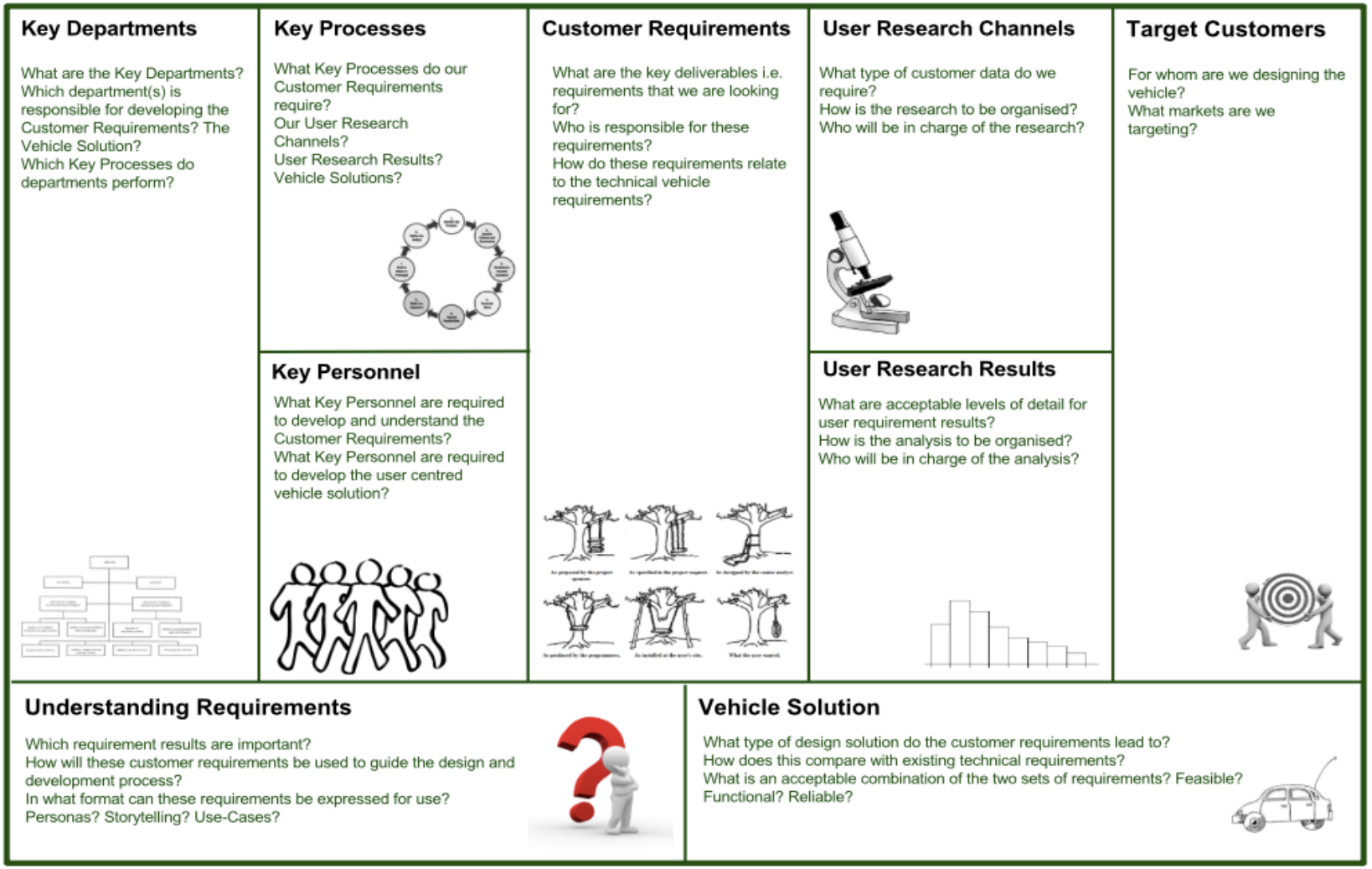


Figure 16 - The User Centred Engineering Canvas (adapted from Osterwalder & Pigneur, 2010)

The proposal of this modified business model canvas is supported by literature, with Bucolo and Matthew (2011) detailing the need for an action plan (i.e. the canvas) to bridge the gap between the strategic and operational sides of a business with regards to the application of design approaches. This suggests that in order to implement UCD at a process level, gaining buy-in through the training of strategic level stakeholders i.e. with managers in UCD application is a reasonable approach.

From the perspective of engineering managers at the firm, this proposal for action also appears viable. As quoted by one participant "the overall company strategy also needs to work in this [UCD] direction. They can then say: the replacement for the vehicle model looks like xyz, because we want to try and sell it in this area, for these types of people, and we have taken this into account (in the development)". That is, developing a tool to help contextualise strategy development and decision making from the perspective of UCD is likely to show the benefits of this approach to managers, which would in turn lead to more customer-orientated decisions from managers who have bought into this approach.

The third opportunity seeks to further address the need of gaining stakeholder buy-in with regards to UCD by addressing the majority, low-level employees within the firm, the engineers.

9.4 Bring UCD into the firm

9.4.1 The status quo

Engineers, typically characterised by Georg and Steffen, represent the majority of key, low-level employees within the vehicle design and development process. Given their key role in company operations, it is vital to ensure adequate buy-in from engineers if the current approach (see Figure 9) is to transition towards a UCD approach (see Figure 15).

Both theory and practical applications of UCD support this notion. Tütek & Ay (2011) argue that there is a need to engage engineers with design approaches being used at the firm to ensure an effective design project free from designer-engineer disputes. This touches upon the issues of departmentalisation occurring within the case firm and automotive manufacturers in general, with engineers, designers and other disciplines typically working apart from one another. Similarly, Pruitt & Grudin (2003) stress the need to clearly communicate the user centred concepts and objectives to the engineers involved in order for them to effectively contribute to the aims of the project.

The results of the research suggest that current operations are heavily influenced by the institutionalised, technology driven company culture. With technical requirements and targets handed down from management representing the main objectives to be met by engineers, the engineers have historically been completely disconnected from the people for whom they are developing vehicles. This disconnect has frequently resulted in an engineering environment where "there is so much that they need to do, and they often don't know why they are doing it that way", "there is no person behind this (the design), that is tangible, that people can relate to and understand why they want this feature".

Engineers are indeed technically minded given their role in the production process, but as one participant said when asked about the usefulness of understanding the user in the overall design:

"if you know the background of the customer, if you know ok he's somebody who's more keen about understanding the technology or if the vehicle is vibrating, or if he just wants some fat car which is just moving at 180 (km/h)…we don't know…then the discussion usually ends there, because we don't know, nobody can answer for what reason did the customer come to the dealership. So I think it is a very good opportunity to use the tool".

Given the apparent amiability of the engineers to the added value brought about via a user centred approach to design, connecting engineers and their users seems to be a matter of finding the right medium for the transfer of information. When propositioned with the concept of personas to centre the user needs in the engineering design process, the following general positive response was received from one German engineer: "that I have a persona supporting me that tells me why I am doing all of this. And this is, for an engineer also tangible, because the data support this".

9.4.2 Facilitating understanding

From discussions with both progressive and conservative engineers like Georg and Steffen, the opportunity to implement a widespread use of UCD by engineers in the firm appears to be dependent on effectively communicating the concept. Given that feedback from firm engineers concerning the benefits of persona and storytelling were predominantly positive, the hurdle to be overcome appeared to be that of educating the firm's engineers about the process and the advantages of combining it with their existing processes.

From the existing literature, discussions with the firm participants, and notes in the reflective journal, it is believed that a two-fold approach is required to establish a low-level transition to UCD adoption amongst the general engineering body:

- Facilitation of effective UCD training for engineers
- Embedding personas and their stories throughout the firm

Building upon the existing training centre at the firm, the 'Experience World', and its use of method experts to teach engineers about newly implement approaches, it is argued that UCD training should be established in this centre (as mentioned in Section 9.3.2 with respect to the implementation of the user centred engineering canvas training tool). The training centre has already implemented a small training

wall regarding personas and storytelling (in 2012-2013), which it has successfully used to teach small numbers of progressive engineers such as those characterised by Steffen.

This training should be built upon, tying into the canvas proposed for use by managers (see Figure 16), and given to all engineers at the firm. Training would be carried out by the designeers, many of whom would have experience with providing the pre-existing training due to their background as method experts at the firm. Such training would provide engineers operating within the 'engineer' stage of vehicle development to better understand the needs of the customers. More specifically, it would allow them to understand and interact with designers and marketers to ensure that the 'engineer', 'design' and 'market' stages were all working towards the same final vehicle product goal.

Complementary to this clear communication of the UCD approach via in-depth training sessions, it is proposed that personas and storytelling could be used to help break down the current departmentalisation within the firm, whilst embedding UCD tools and thinking as part of the everyday firm culture. During the time spent at the firm, the researcher noticed that the cafeterias and coffee halls at the case firm were the only real spaces in which the different disciplines at the firm interacted with each other, and regularly received firm-wide announcements and product unveilings.

It is suggested that if key vehicle model personas and their stories were developed and established at key locations throughout the firm (e.g. as posters etc.), that this would facilitate conversation between designers, engineers and marketers about the actual customers, and help facilitate the desired shift of the firm towards a customer-orientated approach. By bringing together these different disciplines, the 'engineer', 'design' and 'market' stages could be brought

together more easily to interact and contribute to one another under the guidance of the designeers (as proposed in Figure 15).

This targeting and education of general low-level firm employees regarding UCD would complement the high and mid level approaches previously examined, and would add a bottom-up approach to UCD adoption to compliment the preliminary top-down push towards customer orientated design currently taking place. Such an opportunity is supported by research that highlights the importance of engaging low-level employees in cultural transitions, in order to more swiftly adapt to new approaches and thus maintain company performance and competitiveness (Kotter & Heskett, 1992).

9.5 Summary

This section outlined three key opportunities for the adoption and implementation of UCD within the case firm as a response to the challenges identified in Section 8.0. The proposed opportunities sought to address the challenges to UCD in the context of its potential level of impact - high, mid and low - at the firm, and included:

- A shift in company culture; the creation of new roles known as the "designeers", who would act as catalysts for UCD within the firm, ensuring that UCD was implemented at all stages of the vehicle design and development process.
- Communicating a UCD approach; the designeers would attempt to gain buy-in with management over UCD by communicating to managers the proposed user centred engineer canvas. This canvas provides a strategic tool which can be reference to whilst the company vehicle design and development business model is transitioned towards a process methodology that is more customer orientated.
- Bring UCD into the firm; targeting low level employees (mostly engineers), this opportunity involved the increased presence of UCD throughout the firm via persona and storytelling displays in

order to make UCD a part of the everyday company culture and a talking point amongst employees. Furthermore, the adoption of the existing training centre by designeers for the induction of engineers into a UCD approach was seen as an effective channel for wide-scale dissemination of the benefits of the approach.

10.0 Implications and Conclusions

10.1 Introduction

This thesis has investigated the initial stages of an automotive firm's exploratory transition from a solely technology-driven organisation to one that is customer-orientated and user centred in its vehicle design and development. Available literature on automotive manufacturers is dominated by technology driven approaches to process improvement, with alternative user-centred methods confined to marketing or designer-led departments. The research attempts to address the gap in the literature concerning the widespread use of user-centred methods within automotive manufacturers, namely UCD, by examining the challenges and barriers facing the implementation of this approach in a technologically dominated, engineering-centric culture. Furthermore, the research proposes a number of opportunities that could be capitalised upon by the case firm, and automotive firms in general, in order to help transition towards a customer-orientated development process and business model.

Research data was collected using an action research approach, exploiting two key data collection methods: 10 qualitative, semi-structured interviews, and a reflective journal. The in-depth insight into the company culture and the perspectives of its employees allowed the researcher to gain acute understanding of the challenges facing the adoption of UCD on a wider scale, especially amongst engineers.

Thematic analysis of the data identified three key challenges to the successful implementation of UCD throughout the firm:

- A company culture hampered by traditional, hierarchical methods that are focused on technical requirements and technical targets.

- A vehicle development process in which decision making is concentrated with and heavily influenced by firm managers, which in turn reinforces readily identifiable technical targets.
- A traditionally technology driven engineering process that hampers the implementation of a user centred approach. Furthermore, the difficulties in providing evidence of added value opportunities of UCD in the face of such a mindset.

This section addresses the key implications of the research, in terms of its impact on the case firm and on the current theory. The researcher will also reflect upon their time with the research and the impacts they perceive it has, before discusses the contribution of the research findings to the existing body of knowledge in the field. Finally, recommendations for future research will be proposed, based on the findings identified in the research.

10.2 Implications

The findings outlined from the previous research have implications on future work at the case firm, and also on existing theory concerning user centred design and the vehicle design and development process of automotive manufacturers.

10.2.1 Case firm implications

Prior to the engagement of the researcher at the case firm, the firm was only just starting to investigate the specifics behind their decision to transition their business towards a more customer-orientated approach to vehicle development. This initial investigation was predominantly focused on the improvement of existing customer-facing operations, namely sales & marketing. The research outlined in this thesis represents the initial exploration of the firm into adopting a customer-orientated approach to the design and engineering processes.

Preliminary steps involved the development of experimental vehicle personas and subsequent stories for a single vehicle model. The researcher attempt to build upon this initial effort and act as a catalyst to facilitate discussion with staff concerning the implementation of personas, and with them UCD, in the vehicle design and development process. By engaging with engineers and engineering management from a similar point of reference, an engineering background, the research was able to clearly communicate the "design concept" i.e. personas in a matter intelligible to the technically minded participants. This clear communication resulted in the establishment of three key opportunities for potential use by the firm in the future rollout of a customer-orientated approach within the firm.

The first implication was that the hierarchical structure and departmentalised, technical culture at the firm gave rise to the need for a "facilitator" to drive the adoption of UCD with vehicle design and development at the firm. This gave rise to the opportunity for the creation of designeers, multidisciplinary staff tasked with communicating with designers, engineers, managers and marketers to effectively centre vehicle development around user needs and requirements rather than solely around technical targets. Secondly, in order to gain traction with target orientated managers, these designeers would need to propose a suitable business strategy for the implementation of UCD, as represent by the user centred engineering canvas. Finally, the foreseen time saving and decision facilitating benefits of personas and UCD implied the need to effectively communicate these benefits on a wide-scale to engineers within the firm. As a consequence, the researcher proposed the need to establish personas and storytelling medium throughout the firm in order to engage firm employees with the concept of UCD, and to facilitate discussion around the topic amongst the different disciplines and departments.

10.2.2 Theoretical implications

Reflecting upon the key theoretical areas addressed in the research, user centred design and vehicle design and development in the automotive industry, the outcomes of the research give rise to some important implications for future research in the intersection of these fields. Despite existing experimental research into the commercialised implementation of UCD within automotive firms, these projects have been predominantly designer-centric, focusing on UCD use by designers, for designers. This raises the need to move away from such designer-centrism if such user centred approaches are to achieve wider adoption within engineering-centric firms such as automotive manufacturers. Whilst this appears difficult due to the differing backgrounds and focus of engineers and designers, research outcomes imply that the facilitation of effective communication to the disciplines via a specialist third party, i.e. designeers, could help bridge the gap and facilitate the adoption of this practice throughout the vehicle design and development process.

From the perspective of automotive manufacturers, the research suggests that there are three key challenges facing a transition towards a customer-orientated business model not explicitly addressed by existing literature. Firstly, manufacturers are restricted by their traditionally technology-driven culture, which leaves little room for non-technical innovation due to the ingrained thinking and behaviour resulting from the pursuit of technical excellence. Secondly, the concentration of decision making power in the hands of managers means that new approaches must target these stakeholders if they are to gain traction at both a firm-wide and engineering level. Finally, the technical culture within the firm has evolved to disconnect engineers from the end-user, resulting in a lack of engineer understanding concerning approaches that do not involve technical requirements and targets.

In spite of these challenges, the research shows that there are significant opportunities for the implementation of UCD within the automotive industry. Researchers need to carefully examine how UCD can fit into existing vehicle development processes, and how the added value that this approach brings can be communicated to all process stakeholders. The research outlined in this thesis facilitated further discussion regarding the potential use of UCD at a technical level in order to provide the firm with a competitive advantage. Furthermore, the research investigated how UCD approaches could be used to take advantage of the changing business models in the automotive industry, namely the shift towards an increased customer orientation.

10.3 Reflection on engagement

Given the unusual nature of the engagement, namely that of an engineer investigating the implementation of a design approach (UCD) within a heavily engineering-centric firm, it is worthwhile reflecting upon the research. As future researchers are likely to be designers looking to engage with techno-centric firms, it is believed these reflections could help designers overcome traditional designer-engineer miscommunication and conflict.

The initial period of engagement at the firm was spent working as an engineer in an engineering department. This work was not related directly to the research, but provided the researcher a better understanding of the internal operations of the firm and its culture. The automotive manufacturer presented itself as a typical engineering firm, proud of its technical expertise, but also focused on this excellence to the detriment and marginalisation of approaches proposed by designers at the firm i.e. UCD etc. In spite of media articles suggesting a change in direction for the company towards a more customer-orientated approach, day-to-day operations appear

quite distant from the customers for whom the vehicles were being developed.

Initial contact with key stakeholders in the initial investigation into UCD via persona development at the firm suggested significant enthusiasm for the concept. However, as this process was driven by engineers, there did not appear to be a fully developed understanding of personas or the wider application of UCD. Furthermore, given the engineering culture within the firm's operations, these initial steps attempted to create a highly structured, methodological approach to the creation of personas in spite of a lack of understanding as to what exactly they wanted to do with the personas, or the underlying usefulness of a UCD approach to vehicle development.

The researcher commenced research with the firm in an attempt to address this gap in UCD understanding, attempting to frame the questioning in terms of the perceived usefulness and validity of personas in the existing context of normal day-to-day vehicle design and development activities. As the researcher had an engineering background, and had worked within one of the automotive engineering departments at the firm, it was found that they were able to speak the same language as the participants, helping to facilitate effective communication. More specifically, this mutual understanding allowed them to open up to the persona/UCD concept proposed by the researcher and fully reflect upon the benefits and challenges that they perceived would arise from this new approach.

Whilst effective two-way communication facilitated the elucidation of many barriers and opportunities for personas at the firm, it was also made apparent that clear and effective communication would be vital in the future for an effective rollout of UCD within the existing vehicle design and development process at the firm. Many participants, both engineers and designers, reflected upon breakdowns in communication and misunderstandings arising

between the two disciplines in previous projects. They cited their differing backgrounds and inability to "speak the same language" as a key contributing factor in these disputes. The presence of a facilitator able to speak to both disciplines (the researcher) helped to overcome these barriers, and suggests that the proposed multidisciplinary designeers are likely to be necessary for the effective communication and facilitation of the implementation of UCD at the firm.

10.4 Contribution to knowledge

This thesis has addressed the gaps in existing knowledge that were established during the review of pertinent literature. The research sought to address these gaps by striving to answer key research questions, with Table 5 below outlining how the literature has helped to fill these gaps. The contribution of the research to existing knowledge is then further explored in the context of the research problem and questions.

Table 5 - Research contribution to knowledge

Literature Gap	Contribution to Knowledge
There is limited research concerning the implementation of UCD as a new business model strategy in the automotive sector.	The research was able to investigate the challenges and opportunities for UCD within a global automotive manufacturer. Furthermore, specific approaches were proposed for effective future use in UCD implementation.
UCD implementation in the automotive industry has been restricted to use by designers, and further research is required to understand the challenges in companywide adoption, especially amongst the key staff, engineers.	Research was conducted by an engineer, focusing on interviewing engineers and engineering managers as to their perceived barriers and benefits for the implementation of UCD. The research findings addressed likely suitable methods for engaging the engineers in this approach.
Further research is needed to develop potential frameworks to effectively adapt existing vehicle design and	The research helped to provide the groundwork for further research into firm-wide implementation of UCD in automotive

development processes to a UCD approach.	manufacturers. The thesis findings contribute the proposal of an initial framework designed to bring UCD and technology-driven vehicle development processes together, to provide both a practical and theoretical framework for UCD implementation outside of designer-centric teams.

10.4.1 Addressing the first sub-research question

What stereotypes exist that may act as barriers towards the implementation of user centred design by engineers in the company?

Looking at the research results in the context of the first sub-research question, the stereotypes perceived by engineers towards the use of personas, and subsequently of UCD, addressed the lack of exploration of existing literature into the role of engineers in this process. The research contributed to a better understanding of the challenges facing the wide-scale implementation of UCD with an automotive manufacturer, especially amongst engineers.

It was found that UCD approaches using tools such as personas were initially perceived as "foreign" and unintelligible to technology-driven engineers. This was predominantly due to the fact that the use of such design tools were not traditionally communicated to engineers in a manner that they could understand. When combined with the tendency for engineers to lose-interest and marginalise such concepts as "designer related", it was found that the main stereotypes surrounding persona use and UCD implementation related to their designer-centric origins and their lack of comprehension by technically minded engineers.

10.4.2 Addressing the second sub-research question

What benefits are provided to the technical design process by the adoption by engineers of user centred design within complex automotive manufacturing projects?

The second sub-research question contributes to existing knowledge by highlighting the perceived benefits of a UCD approach amongst technical staff, providing an idea of key areas to address when promoting UCD in technical firms in the future.

The key benefit of UCD for engineers in the context of the technical design process was the possible time savings that such an approach could provide. More specifically, engineers and engineering management felt that the ability for such an approach to provide a clearer understanding of customer needs and requirements would help improve the ability for engineers to make key decisions about the development of the vehicle. This improved decision making ability, due to the creation of a point of reference i.e. personas, would subsequently reduce the amount of time spent puzzling over individual decisions and thus save time for all project stakeholders.

10.4.3 Addressing the main research question

What are the key challenges and opportunities in seeking to successfully integrate user centred design through the adoption and implementation of personas in an automotive manufacturing company culture?

In answering the two sub-research questions, the researcher was able to address the overarching challenges and opportunities facing the implementation of UCD within the existing automotive manufacturing vehicle design and development process. This main research question contributes to existing knowledge by providing future researchers with a better understanding of where their efforts should be focused in

order to facilitate the adoption of new, customer-orientated business models via UCD implementation in the vehicle design process.

The three key challenges and three key opportunities for the integration of UCD in the automotive manufacturer via the implementation of personas are outlined in Table 6 below.

Table 6 - Key UCD challenges and opportunities

Challenges	Opportunities
A company culture hampered by traditional, hierarchical methods that are focused on technical requirements and technical targets.	A shift in company culture; the creation of new roles known as the "designeers", who would act as catalysts for UCD within the firm, ensuring that UCD was implemented at all stages of the vehicle design and development process.
A vehicle development process in which decision making is concentrated with and heavily influenced by firm managers, which in turn reinforces readily identifiable technical targets.	Communicating a UCD approach; the designeers would attempt to gain buy-in with management over UCD by communicating to managers the proposed user centred engineer canvas. This canvas provides a strategic framework for the company vehicle design and development business model to be transitioned towards one that is more customer orientated.
A traditionally technology driven engineering process that hampers the implementation of a user centred approach. Furthermore, the difficulties in providing evidence of that added value opportunities of UCD in the face of such a mindset.	Bring UCD into the firm; targeting low level employees (mostly engineers), this opportunity involved the increased presence of UCD throughout the firm via persona and storytelling displays in order to make UCD a part of the everyday company culture and a talking point amongst employees. Furthermore, the adoption of the existing training centre by designeers for the induction of engineers into a UCD approach was seen as an effective channel for wide-scale dissemination of the benefits of the approach.

10.5 Recommendations for future research

The opportunities proposed by the research represent the key focus area for the future continuation of the research detailed in this thesis. More specifically, whilst it was established that tentative buy-in to the concept of UCD through personas was present amongst engineers and engineering managers, the testing of this buy-in through the rollout of a UCD approach within the framework of the existing vehicle development process was not within the scope of the research. It is recommended that future research be completed with the same (or a similar) global automotive manufacturer, to test the potential rollout of UCD via the following three opportunities proposed in Section 9.0:

- The creation of a new role, "designeer", to act as a catalyst for the rollout and widespread implementation of UCD within the firm.
- The implementation of a user centred engineering canvas by the designeers to educate company managers in how to develop a new customer-orientated business model, and to encourage UCD-based decision-making.
- Increased exposure of low-level employees, such as engineers, to UCD through personas and storytelling. Facilitated by designeers through training in the firm's training centre and through persona and storytelling displays throughout the firm.

10.6 Conclusions

This thesis has investigated the potential for the widespread adoption of user centred design within a global automotive manufacturer. Completed through an action research approach, the research attempted to discern the challenges and opportunities facing the implementation of UCD within the existing vehicle design and development process at the firm. Moreover, the study attempted to broaden the focus of existing UCD studies, looking at the potential use

and acceptance of UCD tools such as personas by engineers and managers, instead of solely by designers.

During the course of the research, three key challenges to the adoption of UCD within the case study firm were uncovered:

- Cultural and institutional inertia within the firm acts as a barrier to the adoption of new ideas, due to the focus of existing firm behaviour and thinking on technology centred design;
- The concentration of design process decision-making in the hands of management necessitates gaining buy-in from firm managers if user centred design is to be implemented within the existing vehicle design and development process, and;
- The institutionalised, technology driven requirements culture at the firm has resulted in engineers becoming disconnected from the customers for whom they are designing a vehicle. Thus the adoption of user centred design requires gaining buy-in with firm engineers, who are trained to focus on achieving technical targets handed down by management.

Subsequent analysis of these challenges and the research data resulted in the proposal of three key opportunities that could be used to overcome existing barriers to UCD within the firm, namely:

- The creation of a new role, "designeer", to act as a catalyst for the rollout and widespread implementation of UCD within the firm.
- The implementation of a user centred engineering canvas by the designeers to provide a new customer-orientated business model to company managers and encourage UCD-based decision-making.
- Increased exposure of low-level employees, such as engineers, to UCD through personas and storytelling. Facilitated by

designeers through training in the firm's training centre and through persona and storytelling displays throughout the firm.

This research represents a significant step in the field of UCD within the automotive industry. Given the lack of research into user centred design outside of designer-centric projects and teams, the thesis findings provide new insight into the adoption of design methodologies, such as UCD, within extremely technologically orientated firms and product development teams. Furthermore, the research reiterates the oft-forgotten sentiment that engineers and designers can effectively work together with joint focus, in spite of their differing backgrounds. It is hoped that this research represents the first step in refining existing vehicle design and development process to take advantage of both design and engineering-based thinking, and will enable a future filled with more suitable, enjoyable, and functional vehicles for customers to drive.

11.0 References

Abras, C, Maloney-Krichmar, D & Preece, J 2004, 'User-Centered Design', in Bainbridge, K (ed), *Encyclopedia of Human-Computer Ineraction*, Sage Publications, USA.

Accenture 2010, 'The New Growth Agenda in Automotive: Achieving High Performance by Focusing Marketing and Sales on New Faces, Places and Spaces', viewed July 24 2013, <http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture_Automotive_Sales_Marketing.pdf>.

Ali, N. A. M, Gafar, M. H. A & Akbar, J 2013, 'Enhancing Promotional Strategies Within Automotive Companies in Malaysia', *Proceedings Economics and Finance*, vol. 7, pp. 158-163.

Armstrong, J 2008, 'Design Matters: The Organsation and Principles of Engineering Design', Springer-Verlag, London, U.K.

Barnard, R. H 2002, 'Automotive Engineering Development, in J Happian-Smith (ed), *An Introduction to Modern Vehicle Design*, Butterworth-Heinemann, Oxford, U.K., pp. 1-26.

Beecroft, D 1927, 'Equipment and Control of the Motor Vehicle', *Annals of the American Academy of Political and Social Science*, vol. 133, pp. 140-143.

Bhimani, A & Mulder, P. S 2001, 'Managing processes, quality, and costs: A case study', *Journal of Cost Management*, vol. 15, no. 2, pp. 28-32.

Braun, V & Clarke, V 2006, 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, vol. 3 no. 2, pp. 77-101.

Brydon-Miller, M, Greenwood, D & Maguire, P 2003, 'Why action research?', *Action Research*, vol.1 no. 1, pp. 9-28.

Bucolo, S & Matthews, JH 2010, 'Using a Design Led Disruptive Innovation Approach to Develop New Services: Practicing Innovation

in Times of Discontinuity'. In proceedings of *CINet Conference 2010*, Zürich, Switzerland.

Bucolo, S & Matthews, JH 2011, 'A conceptual model to link deep customer insights to both growth opportunities and organisational strategy in SME's as part of a design led transformation journey', in proceedings of *Design Management Toward A New Era of Innovation*, Hong Kong Convention and Exhibition Center, Hong Kong.

Bucolo, S & Matthews, JH 2011a, 'Design led innovation: exploring the synthesis of needs, technologies and business models', in proceedings of *Participatory Interaction Conference*, Sønderborg, Denmark, January 13-15, 2011.

Bucolo, S & Wrigley, C 2011, 'Sustaining social innovation enterprises through a design led innovation framework', in proceedings of *Business Design Conference - a discursive summary*, CreateSpace Independent Publishing Platform.

Calabria, T 2005, 'An introduction to personas and how to create them', Step Two Designs Pty Ltd, Australia.

Calde, S, Goodwin, K & Reimann, R 2002, 'SHS Orcas: The first integrated information system for long-term healthcare facility management', in proceedings of *Conference on Human Factors and Computing Systems*, AIGA Experience Design Forum, New York.

Chamorro-Koc, Adkins & Bucolo 2012, 'Using scenarios to explore the social aspects of design led innovations', in proceedings of *Projecting Design 2012: Global Design Bridge*, Santiago, Chile, pp. 186-191.

Clark, K. B, Chew, W. B, & Fujimoto, T 1987, 'Product Development in the World Auto Industry', *Brookings Papers on Economic Activity*, vol. 1987 no. 3, pp. 729-781.

Clarke, C 2003, 'Forms and function of standardisation in production systems of the automotive industry: the case of Mercedes-Benz', Master Thesis Dissertation, Freie Universität Berlin, Germany.

Cooper, A 2004, *The inmates are running the asylum*, Sams Publishing, USA.

Costello, P 2011, 'Effective Action Researcher: Developing Reflective Thinking and Practice', Continuum, London, UK.

Daly, J, Kellehear, A & Gliksman, M 1997, 'The public health researcher: A methodological approach', Oxford University Press, Melbourne, Australia, pp. 611-618.

Dell'Era C, Marchesi, A & Verganti, R 2010, 'Mastering technologies in design-driven innovations: how two Italian furniture companies make design a central part of their innovation process', *Research Technology Management*, pp. 12-23.

Deloitte 2008, 'Ladies and Gentlemen, Start Your Service Engines', viewed July 24 2013, <http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/dtt_ladiesandgentlemenstartyourserviceengines_v2.pdf>.

Deloitte 2009, 'Convergence in the Automotive Industry: Securing advantages with new ideas', viewed July 24 2013, <http://www.deloitte.com/assets/Dcom-Netherlands/Local%20Assets/Documents/EN/Industries/Manufacturing/nl_en_MFG_Convergence_Automotive_Industry_2009_DELOITTE.pdf>.

Deloitte 2009a, 'Accelerating toward 2020 – An automotive industry transformed', viewed July 8 2013, <https://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/A%20New%20Era_Online_final.pdf>.

Design Museum 2013, 'Design process at the Ford Motor Company', viewed July 10 2013, <http://designmuseum.org/httpd/pdf/Ford.pdf>.

Dick, P 2004, 'Discourse Analysis', in C Cassell & G Symon (eds), *Essential Guide to Qualitative Methods in Organizational Research*, Sage Publication, London: UK, pp. 203-213.

Dreyer, R 2009, 'Automotive History', Bentley Historical Library: University of Michigan, viewed 22 September 2014, <http://bentley.umich.edu/research/guides/automotive/>.

Ellis, L. B & Crookes, P. A, 1998, 'Philosophical and theoretical underpinnings of research', In Crookes, P. A & Davies, S (eds), *Research Into Practice: Essential Skills for Reading and Applying Research in Nursing and Health Care*, Bailliere Tindall, London, UK, pp. 85-115.

European Automobile Manufacturers Association (ACEA) 2012, 'The Automobile Industry Pocket Guide 2012', viewed June 20 2013, <http://www.acea.be/images/uploads/files/ACEA_POCKET_GUIDE_2012_UPDATED.pdf>.

Fink, J 1990, 'The Automobile Age', MIT Press, Massachusetts, USA.

Ford, H 1922, 'My Life and Work', The Country Life Press, New York, USA.

Gaffney, G 2014, 'Scenarios', Information and Design Ltd, Melbourne, Australia.

Gatherspace 2014, 'Use Case Examples', viewed 10 October 2014, <http://www.gatherspace.com/static/use_case_example.html>.

Gebauer, C. S 2013, 'Bachelor Thesis', Technical University of Munich, Munich, Germany.

Gellatly, AW, Hansen, C, Highstrom M, & Weiss, JP 2010, 'Journey: General Motors' Move to Incorporate Contextual Design Into Its Next Generation of Automotive HMI Designs', *AutomotiveUI 2010*, Pennsylvania, USA, pp. 156-161.

Georges, A & Romme, L 2004, 'Action Research, Emancipation and Design Thinking', *Journal of Community & Applied Social Psychology*, vol. 14, no. 1, pp. 495-499.

Giacomin, J 2012, 'Human Centred Design of 21st Century Automobiles', Human Centred Design Institute, Brunel University, UK.

Goel, A, Smith, F & West, J 2005, Beyond Sticky Stamps: Transforming Customer Experience at the US Postal Service, *Design Management Review*, vol. 16, no. 4, pp. 25-33.

Gould, J. D & Lewis, C 1985, 'Designing for usability: key principles and what designers think', *Communications of the ACM*, vol. 28 no. 3, pp. 300-311.

Guest, G, MacQueen, K. M & Namey, E. E 2012, 'Applied Thematic Analysis', SAGE Publications, London, UK.

Gulliksen, J, Goransson, B, Boivie, I, Blomkvist, S, Persson, J & Cajander, A 2003, 'Key principles for user centred systems design', *Behaviour & Information Technology*, vol. 22 no. 6, pp. 397-409.

Gulliksen, J, Lantz, A, Boivie, I 1999, 'User Centered Design in Practice - Problems and Possibilities', Centre for User Orientated IT Design, Royal Institute of Technology Stockholm, viewed 11 October 2014, <http://www.nada.kth.se/cid/pdf/cid_40.pdf>.

Gunasekaran, A & Ngai, E. W. T 2005, 'Build-to-order supply chain management: a literature review and framework for development', *Journal of Operations Management*, vol. 23, pp. 423-451.

Haik, Y & Shahin, T 2011, *Engineering Design Process*, 2nd edn, Cengage Learning, Stamford, USA.

HHS Digital Communications Division 2014, 'User-Centered Design Process Map', U.S. Department of Health & Human Services, viewed October 10 2014, <http://www.usability.gov/how-to-and-tools/resources/ucd-map.html>.

Hill, D 2010, 'Emotionomics: leveraging emotions for business success', Kogan Page Ltd., London, UK.

Holt, D, & Cameron, D 2010, 'Cultural strategy: using innovative ideologies to build breakthrough brands', Oxford University Press, Oxford, UK.

Hudson, W 2001, 'Toward unified models in user-centered and object-oriented design', in M. Van Harmelen (ed) *Object Modeling and User Interface Design: Designing Interactive Systems*, Addison-Wesley, Boston, USA, pp. 313-362.

IBM 2012. 'Driving customer change through the automotive industry', IBM Smarter Analytics: Automotive, viewed September 15 2014, <http://www-935.ibm.com/services/multimedia/IBM_BAO_POV_AUTO_FINAL.pdf>.

International Organization for Standardization 2010, *Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems*, (ISO 9241-210:2010), ISO.

Jaafarnia, M & Bass, A 2011, 'Tracing the Evolution of Automobile design: Factors influencing the development of aesthetics in automobiles from 1885 to the present.', in proceedings of *International conference on Innovative Methods in Product Design*, Venice, Italy, June 15-19, 2011.

Jaikumar, R 1986, 'Postindustrial manufacturing', *Harvard Business Review*, November-December, pp. 69-76.

James, W 1928, 'Engine and Car Performance', SAE Technical Paper 280003, doi: 10.4271/280003

Karim, K 2001, 'Assessing the strengths and weaknesses of action research', *Nursing Standard*, vol. 15 no. 26, pp. 33-35.

Khadani, S 2005, 'Engineering Design Process: Education Transfer Plan', Industry Initiatives for Science and Maths, Santa Clara, CA, USA.

Klepper, S 2001, 'The Evolution of the U.S. Automobile Industry and Detroit as its Capital', Carnegie Mellon University, viewed 12 September 2014, <http://www.druid.dk/uploads/tx_picturedb/dw2002-440.pdf>.

Knobel, M, Hassenzahl, M, Lamara, M, Sattler, T, Schumann, J, Eckoldt, K & Butz, A 2012, 'Clique Trip: Feeling Related in Different Cars', in proceedings of *Designing Interactive Systems 2012*, Newcastle, UK, pp. 29-37.

Koch, N 2004, 'The three threats of action research: a discussion of methodological antidotes in the context of an information systems study', *Decision Support Systems*, vol. 37 no. 1, pp. 265-286.

Koch, N 2013, 'Action Research: Its Nature and Relationship to Human-Computer Interaction', Interaction Design Foundation, Denmark.

Koch, N, McQueen, R. J & Scott, J. L 1997, 'Can action research be made more rigorous in a positivist sense? The contribution of an iterative approach', *Journal of Systems and Information Technology*, vol. 1 no. 1, pp. 1-24.

Kotter, J. P & Heskett, J. L 1992, 'Corporate Culture and Performance', The Free Press, New York, USA.

Leaney, P. G & Marshall, R 2002, 'The manufacturing challenge for automotive designers', in J Happian-Smith (ed), *An Introduction to Modern Vehicle Design*, Butterworth-Heinemann, Oxford, U.K., pp. 57-92.

Leitch, R & Day, C 2000, 'Action research and reflective practice: towards a holistic view', *Educational Action Research*, vol. 8 no. 1, pp. 179-193.

Lowdermilk, T 2013, 'User-Centered Design', O'Reilly Media Inc., Sebastopol, CA, USA.

Marshall, R, Cook, S, Mitchell, V, Summerskill, S, Haines, V, Maguire, M, Sims, R, Gyi, D, & Case, K 2013, Design and evaluation: End users, user datasets and personas, *Applied Ergonomics*, in-press, pp. 1-7.

Mattison, D 2006, 'Superior, Efficient, and Complete Automotive Concept Design', *Autodesk*, viewed October 3 2014, <http://www.envisageuk.com/pdf/Automotive_Design_Whitepaper_Casestudy.pdf>.

McDonnell, A 1998, 'Factors which may inhibit the utilisation of research findings in practice: some solutions', In Crookes P & Davies S (eds), *Research into Practice*. Baillière Tindall, Edinburgh, UK.

McKinsey 2013, 'The road to 2020 and beyond: What's driving the global automotive industry?', McKinsey & Company, Germany.

McKinsey 2014, 'Innovating Automotive Retail', McKinsey & Company, Germany.

Mehra, B 2002, 'Bias in Qualitative Research: Voices from an Online Classroom', *The Qualitative Report*, vol. 7 no. 1.

Miaskiewicz, T & Kozar, K 2011, 'Personas and user-centered design: How can personas benefit product design processes?', *Design Studies*, vol. 32, no. 5, pp. 417-430.

Michalek, JJ, Feinberg FM & Papalambros PY 2005, 'Linking Marketing and Engineering Product Design Decisions via Analytical Target Cascading', *The Journal of Product Innovation Management*, vol. 22, no. 1, pp. 42-62.

Michigan University of Technology (MTU) 2006, 'The Engineering Design Process', viewed July 9 2013, <http://www.me.mtu.edu/~nels/3957Fall06/week2lec.pdf>.

Midler, C & Navarre, C 2004, 'Chapter Fifty-Five: Project Management in the Automotive Industry', in Morris & Pinto (eds), *The Wiley Guide to*

Managing Projects, John Wiley & Sons, New Jersey, USA, pp. 1368-1388.

Moore, D. W 1998, 'Headlamp History and Harmization', The University of Michigan Transport Research Institute, Michigan, U.S.A.

Mulder, S & Yaar, Z 2007, 'The User is Always Right: A Practical Guide to Creating Persons for the Web', New Riders, Berkley, CA, USA.

National Academy of Engineering 2014, 'Automobile – Timeline', viewed 17 September 2014, <http://www.greatachievements.org/?id=3880>.

Norman, D 2004, 'Emotional Design: Why We Love (or Hate) Everyday Things', Basic Books, New York, USA.

Norman, D 2005, 'Human-Centered Design Considered Harmful', *Interactions*, vol. 12 no. 4, pp. 14-19.

Oliver Wyman Group 2007, '2015 car innovation: A comprehensive study on innovation in the automotive industry', viewed July 10 2013, <http://www.emic-bg.org/files/CarInnovation2015_engl.pdf>.

Onwuegbuzie, A. J & Leech, N. L 2007, 'Sampling Designs in Qualitative Research: Making the Sampling Process More Public', *The Qualitative Report*, vol. 12 no. 2, pp. 238-254

Ortlipp, M 2008, 'Keeping and Using Reflective Journals in the Qualitative Research Process', *The Qualitative Report*, vol. 13 no. 4, pp. 695-705

Osterwalder, A & Pigneur, Y 2010, 'Business Model Generation', Wiley & Sons Inc., New Jersey, USA.

Parry, G & Graves, A, 2008. 'Build to Order: The Road to the 5-Day Car', Springer-Verlag, London, U.K.

Parry, G & Roehrich, J 2013, 'Automotive Enterprise Transformation: Build to Order as a Sustainable and Innovative Strategy for the

Automotive Industry?', *Journal of Enterprise Transformation*, vol. 3, no. 1, pp. 33-52.

Patton, M. Q & Cochran, M 2002, 'A Guide to Using Qualitative Research Methodology', Medecins Sans Frontieres, viewed 14 January 2015, < http://fieldresearch.msf.org/msf/bitstream/10144/84230/1/Qualitative%20research%20methodology.pdf>.

Ponterotto, J. G 2006, 'Brief Note on the Origins, Evolution, and Meaning of the Qualitative Research Concept "Thick Description"', *The Qualitative Report*, vol. 11 no. 3, pp. 538-549.

Popplewell, R & Haymann, R 2012, 'Where, how, and why are Action Research approaches used by international development non-governmental organisations?', International NGO Training and Research Centre, viewed 22 October 2014, <http://www.intrac.org/data/files/resources/752/Briefing-Paper-32-Where-how-and-why-are-Action-Research-approaches-used-by-international-development-non-governmental-organisations.pdf>.

Pruitt, J & Grudin, J 2003, 'Personas: Practice and Theory', *Microsoft Research*, viewed 2 March 2014, <http://research.microsoft.com/en-us/um/redmond/groups/coet/grudin/personas/old%20versions/pruitt-grudinold.pdf>.

Pruitt, J & Grudin, J 2006, 'Personas: Practice and Theory', *Microsoft Research*, viewed 15 October 2014, <http://research.microsoft.com/en-us/um/people/jgrudin/publications/personas/designchapter.pdf>.

Ramsey, M 2013, 'Design Revolution Sweeps the Auto Industry', *The Wall Street Journal*, viewed 28 September 2014, <http://online.wsj.com/news/articles/SB10001424127887323968704578649862128698352>.

Ravasi, D & Schultz, M 2006, 'Responding to organizational identity threats: Exploring the role of organizational culture', *Academy of Management Journal*, vol 39 no. 3, pp. 433-458.

Reason, P & Bradbury, H 2007, 'The SAGE Handbook of Action Research: Participative Inquiry and Practice', SAGE Publications, London, UK.

RMIT Study and Learning Centre 2012, 'Research Writing Group kit – Approaches: The reflective journal', Royal Melbourne Institute of Technology, viewed on 20 October 2012, <http://emedia.rmit.edu.au/learninglab/sites/emedia.rmit.edu.au.learninglab/files/Approaches-The%20reflective%20journal.pdf>.

Papadakis, V. M, Lioukas, S & Chambers, D 1998, 'Strategic Decision-Making Processes: The Role of Management and Context', *Strategic Management Journal*, vol. 19 no. 2, pp. 115-147.

Patton, P 2009 'Before Creating the Car, Ford Designs the Driver', *New York Times*, viewed on 10 September 2014, <http://www.nytimes.com/2009/07/19/automobiles/19design.html?pagewanted=all&_r=0>.

Saldana, J 2009, 'The Coding Manual for Qualitative Researchers', SAGE Publications, London, UK.

Sandretto, S 2007, 'Discussion Paper: Action Research for Social Justice', Teaching and Learning Research Initiative New Zealand, viewed 22 October 2014, <http://www.tlri.org.nz/sites/default/files/pages/action-research.pdf>.

Satake, I, Xin, J. H, Tianming, T, Hansuabesai, A, Ando, K, Sato, T, Kajiwara, K & Ohsawa, S 2011, 'A comparative study of the emotional assessment of automotive exterior colors in Asia', *Progress in Organic Coatings*, vol. 72, pp. 528-540.

Shehab, E. M, & Abdalla, H. S 2001, 'Manufacturing cost modelling for concurrent product development', *Robotics and Computer Integrated Manufacturing*, vol. 17, pp. 341-353.

Soderberg, L. G 1989, 'Facing up to the engineering gap', *The McKinsey Quarterly*, Spring, pp. 2-18.

Sorensen, D 2006, 'The Automotive Development Process: A Real Options Analysis', Gabler Edition Wissenschaft, Stuttgart, Germany.

Stastista, 2014, 'International car sales by region 1990-2013', viewed 24 September 2014, <http://www.statista.com/statistics/200005/international-car-sales-by-region-since-1990/>.

Steen, M 2012, 'Human-Centered Design as a Fragile Encounter', *Design Issues*, vol. 28 no. 1, pp. 72-80.

Strong, D. S 2014, 'The Engineering Design Process: Methodology and Responsibility', *APSC 200 Engineering and Design Practice II*, http://www.powershow.com/view/15008f-ZjY0Z/D_S_Strong_Queen_powerpoint_ppt_presentation, Queen's University, viewed 5 October 2014.

Suhonen, J 2009, 'Week 5: R&D methods in computing: action research, development research, design research and constructive research', University of Eastern Finland, viewed 22 October 2014, <http://cs.joensuu.fi/pages/suhonen/SciMet2009/week5_R&D_methods.pdf>.

Tischler, L 2004, 'Peak Performers: Four Masters Who are Leading the World of Design', *Fast Company*, vol. June 2004, pp. 65.

Tschlegi, M 2012, 'User Experience Design for Vehicles', in proceedings of *4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, Portsmouth, USA, Tutorial #5.

Tütek, H & Ay, C 2011, 'Resolving Conflict Between Marketing and Engineering: A Quest for Effective Integration', Celal Bayer University, viewed 10 July 2013, <http://www.opf.slu.cz/vvr/akce/turecko/pdf/Tutek.pdf>.

University of Colorado Boulder 2014, 'The History of the Automobile', Center for Lifelong Learning and Design, viewed 2 September 2014, <http://l3d.cs.colorado.edu/systems/agentsheets/new-vista/automobile/history.html>.

User Experience Professionals Association 2014, 'What is User-Centered Design?', viewed 7 October 2014, <http://www.usabilityprofessionals.org/usability_resources/about_usability/what_is_ucd.html>.

U.S. Library of Congress, 2014, 'Global Automotive Industry', viewed 20 September 2014, <http://www.loc.gov/rr/business/BERA/issue2/industry.html>.

Viswanathan, B 2013, 'Why Are Cars Not Getting Cheap Even With Better Economies of Scale?' Forbes, viewed 29 September 2014, <http://www.forbes.com/sites/quora/2013/05/07/why-are-cars-not-getting-cheap-even-with-better-economies-of-scale/>.

Vredenburg, K, Isensee, S, & Righi, C 2002, 'User-Centered Design: An Integrated Approach', Prentice-Hall, New Jersey, USA.

Vredenburg, K, Mao, J. Y, Smith, P. W & Carey, T 2002, 'A Survey of User-Centered Design Practice', in proceedings of *CHI 2002 Conference on Human Factors in Computing Systems*, Minneapolis, USA, April 20-25, 2002.

Wallach, D, & Scholz, S. C 2012, 'User-Centered Design: Why and How to Put Users First in Software Development', in Maedche, A, Botzenhardt, A, & Neer, L (eds), *Software for People*, Springer, Germany, pp. 11-38.

Wang, X 2007, 'Personas in User Interface Design', Department of Computer Science, University of Calgary, viewed 15 October 2014, <http://pages.cpsc.ucalgary.ca/~saul/wiki/uploads/CPSC681/topic-wan-personas.pdf>.

Ward, A, Runcie, E & Morris, L 2009, 'Embedding innovation: design thinking for small enterprises', *Journal of Business Strategy*, vol. 30, no. 2, pp. 78-84.

Webber, A, Manning, H & McInnes, A 2007, 'Personas Drive Microsoft Dynamics UI Design', Microsoft Dynamics, viewed 14 October 2014, <https://www.forrester.com/Personas+Drive+Microsoft+Dynamics+UI+Design/fulltext/-/E-RES43556>.

Web Usability Initiative 2008, 'Notes on User Centered Design Process (UCD)', viewed 8 October 2014, <http://www.w3.org/WAI/redesign/ucd>.

Weinstein, M 2014, 'TAMS Analyzer for Macintosh OS X', viewed 21 October 2014, <http://tamsys.sourceforge.net/>.

Wells, P 2013, 'Sustainable business models and the automotive industry: A commentary', *IIMB Management Review*, 2013, pp. 1-12.

Wijnen, R 2013, 'New Business Models in the Car Industry', viewed 30 November 2014, <http://www.businessmodelsinc.com/new-business-models-in-the-car-industry/>.

Wrigley, C & Bucolo, S 2012, 'I just want to design a sexy flying car! Teaching design-led innovation to designers', in proceedings of *Projecting Design*, Santiago, Chile, November 14-17, 2012.

Wrigely, C 2013, 'Educating the 'Design Innovation Catalyst' for change', in Sugiyama, Kazuo (Eds), *Consilience and Innovation in Design Proceedings and Program vol. 1*, Shibaura Institute of Technology, Tokyo, Japan, pp. 3547-3557.

Wrigley, C 2014, 'GSN486: Design Thinking (Lecture)', Queensland University of Technology, Brisbane, Australia.

Zott, C and Amit, R 2010, 'Business Model Design: An Activity System Perspective', *Long Range Planning*, vol. 42 no. 2-3, pp. 216-226.

12.0 Appendix

12.1 Appendix A – Coursework

The course 'IFN001 - Advanced Information Retrieval Skills (AIRS)' was completed in 2012.

12.2 Appendix B – Interview format

1. Can you start off by just telling me about your role within the company and how your role supports the organisation?
2. What are the major challenges that you face on a day-to-day basis? [Probes: Technical issues? Personnel issues?]
3. When people ask, what does your company do, how do you describe what it does? [Probes: As an engineering company? A car supplier? An automotive manufacturer? A customer focused solutions finder?]
4. How do you think customers perceive the company? The brand? [Probes: An innovator? An industry leader? Why do you think this is so?]
5. To what level do the design and engineering departments communicate with one another and are aware of another's roles? [Probes: Totally involved from the beginning of the project? Or do you have little to do with one another? How exactly does it tend to work (on average) here at the firm?]
    a. Do you think communication and understanding is an important factor in enabling a smooth design process/vehicle development in a project?
        - Have you found there have been issues in past projects between designers and engineering/technical staff? What were these issues? [Probes: How have they impacted on the

vehicle development process?] How do you think they could be solved in future projects?

6. *Discuss my role in organisation and purpose/objectives of why I am here.* [Probes: What are your thoughts on this type of project? What are your views of how this project may or may not assist the company as a whole?]

7. I see some resistance/hesitance from engineers (in general, from my experience as an engineer dealing with engineers) surrounding customer-driven design and designers/marketers approach to design (such as in vehicle design), compared to the traditionally 'technology driven' engineering approach; from your perspective, why do you think this is so? [If you disagree, why do you think this is not a problem?]

8. Specifically regarding your role, have you had any past experiences in vehicle design projects which involved marketers and/or designers? [Probes: How did you feel about such projects? Did the objectives of the marketers/designers clash with your/the engineers' objectives? [For example, the designers had a certain opinion about a design, and the engineers disagreed] If so, how? What was the outcome of such clashes? Did the designers give way to the engineers, vice-versa, or did something else happen?]

9. Have you had any past experiences in vehicle design projects that involved the use of personas/persona design [*such as that being developed at the firm; show example of firm personas and 'data'*]? [Probes: If yes, how did you feel about such projects? Did this focus help or get in the way of the technical objectives used by the engineers? If no, based on the definition of personas as:

"fictional, detailed archetypical characters that represent distinct groupings of behaviours, goals and motivations" (Calde, Goodwin & Reimann, 2002) which act as 'stand-ins' for real users and help to guide decisions about functionality and design (Calabria, 2005), and the example of firm personas;

do you think using personas in engineering design work would be useful? Why/why not? Do you think other engineers in the company would find this approach useful? Why/why not?]

10. Specifically regarding your role at the firm, what are the challenges you think you may face when dealing with personas if they become standard practice in vehicle design? [Probes: Would this result in changes in the engineering design process? Issues related to engineers integrating this process into their technical development process?] [*In examining personas – I am also examining the culture of the company and how they respond to the concept of change and change implementation.*]

11. How do you think the creation of personas [show example firm personas again] would then translate to the design of the vehicle? How do you think the physical design would be influenced/affected? Would the design changes caused by the personas be tested with customers? If so, how?

11. What are the biggest challenges from your perspective in being able to collectively change across all departments? Previously, how has change been managed? (KANO? Standardised vehicle/design platform? Previously implemented "new processes", etc.)

a. Why do you think it's done this way?

b. Do you think it could be done differently? If so, how?

12. How is new product development approached in the company? How are new products introduced to the departments and processes?

a. Are they effective?

b. How are these products developed for non-Germany/non-European markets?

i. Have there been any cases of vehicle designs not working in foreign markets? Why do you think this is the case?

13. Do you think the company is receptive to change? How do people in the company respond to change? [For example, how do they react when there are new company regulations/processes that have to be followed in their day-to-day work?] [Probes: Why do you think that is the case? Could anything be done differently? If so, what, why?]

12.3 Appendix C – Example interview transcription

Interview 6

To start, is it possible to get an overview of what you do at [redacted]?

Ok, my role is comparable to that of Monika Weber. We support the ([redacted]) divisions with methodology, and moderate workshops; we tried these storyboards and storytelling with a ‚panorama roof' last year. This is one of many methods, and what is most interesting is always trying to figure out what works best. With these customer profiles you always have the question: is it information that a team has at the beginning of a project e.g. xyz objectives and requirements management. So for example, the F30 is very special for 3-4 customer groups. As far as I know, a F30 also has to fill the requirements of a 3-series for every customer. I think there are always more specific areas where every customer cannot be satisfied. For example, it is like this for the seating position, you will only ever be able to get it right for about 95% of people. For the small portion it is important to realise we have to weigh paying more to reach 100% of our customers, or we say our main customers, this 95%, are exactly the customers that we are targeting for this F30.

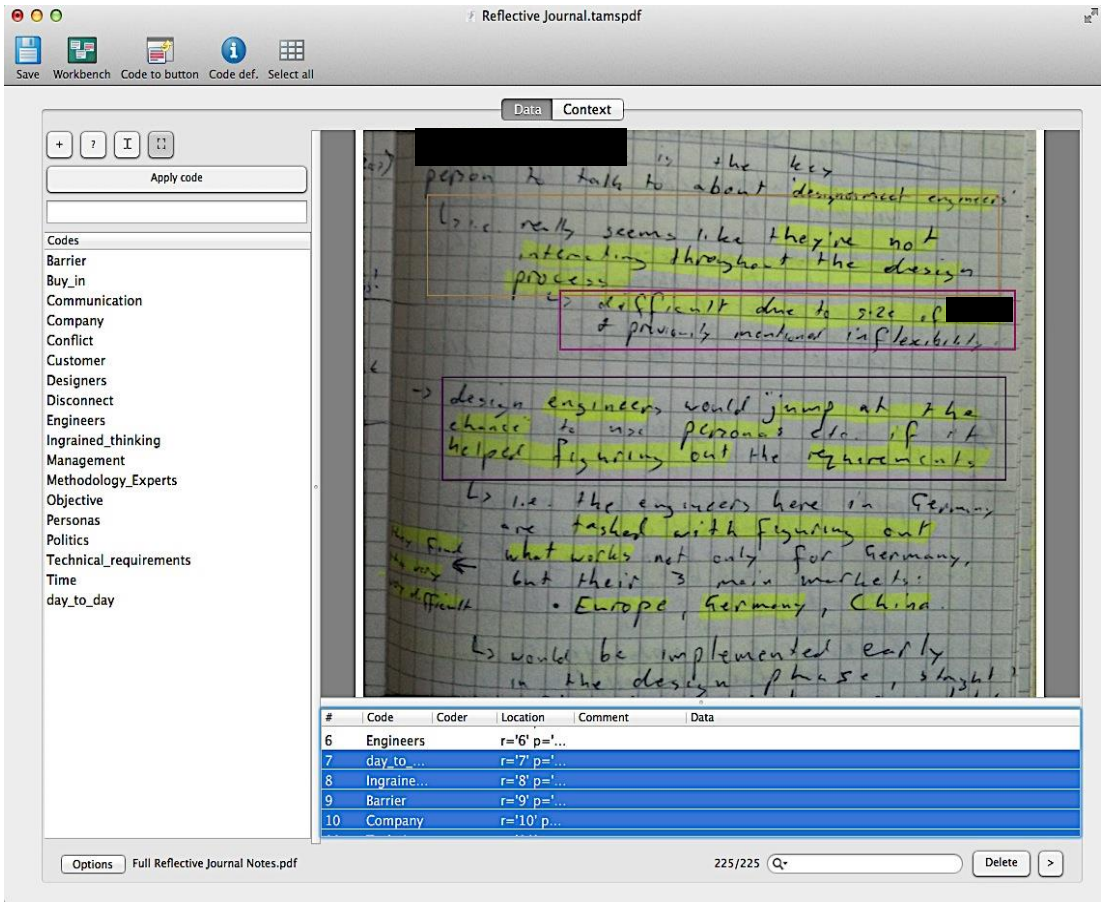
And what are the methods to understand all of this?

So, from my point of view the first step is to find this out. Maybe people need to see this from two perspectives: one side is the storyboard, where you choose a concept for a customer and develop it. I think that this is something really good, if you can come up with something special for a particular vehicle, where the customers are more concrete. If you select a whole line of vehicles, then I think it would be quite difficult. The danger is very high, that you develop a concept and go to the project leader and say: I have developed a concept that fits the customer perfectly. Then the project leader says: I have 10 others that I need to make happy. So, I can see this being more applicable for really specific things. So this large panorama roof, that we have, that won't be installed in all vehicles. And if you think of a touring vehicle (larger [redacted]s), then I could come up with specific customers, as no 20 year old would be driving a touring vehicle.

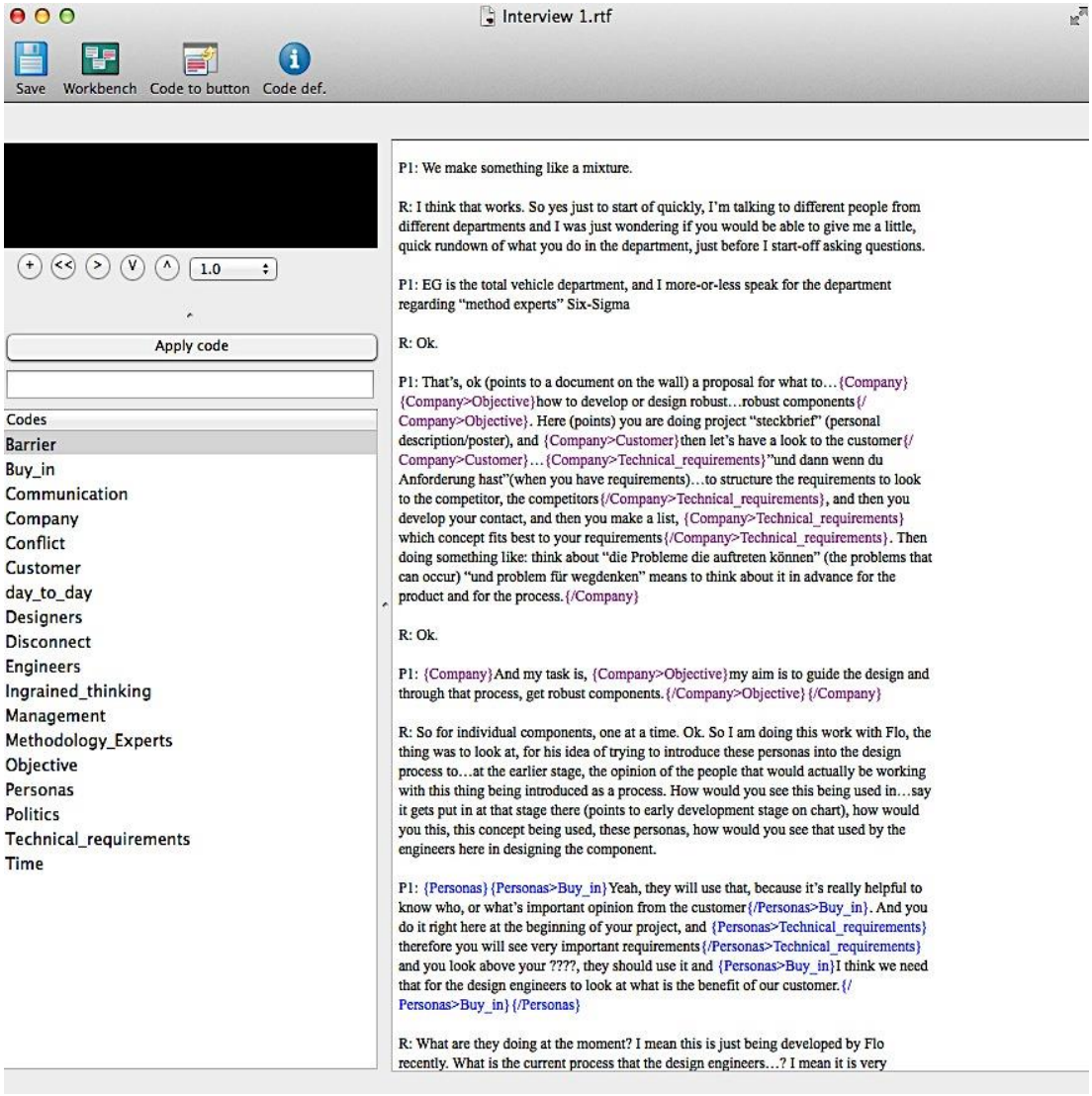
For new methods, like personas and storyboards, how would they normally be accepted in your department? Would they be used?

We have developed an ongoing discussion with Florian about these points, and have only addressed these points. As an example: if you take a persona and go to the developers (engineers) and say: we've come up with a story...so, we need to take the next step and find out how the developer would react to such a proposition. It is like this, there are development teams in projects or in a product line, they take over the concept from the advanced development group (i.e. initial designers). The team leader has no influence over whether the concept is relevant to real customers, because they are only working on small things. If it was something like what I have here (in my department), where we can go to the advanced designers directly from our department as they are next door... However, I believe that this is the right place for this method (with the initial designers).

12.4 Appendix D – Example reflective journal entry and analysis

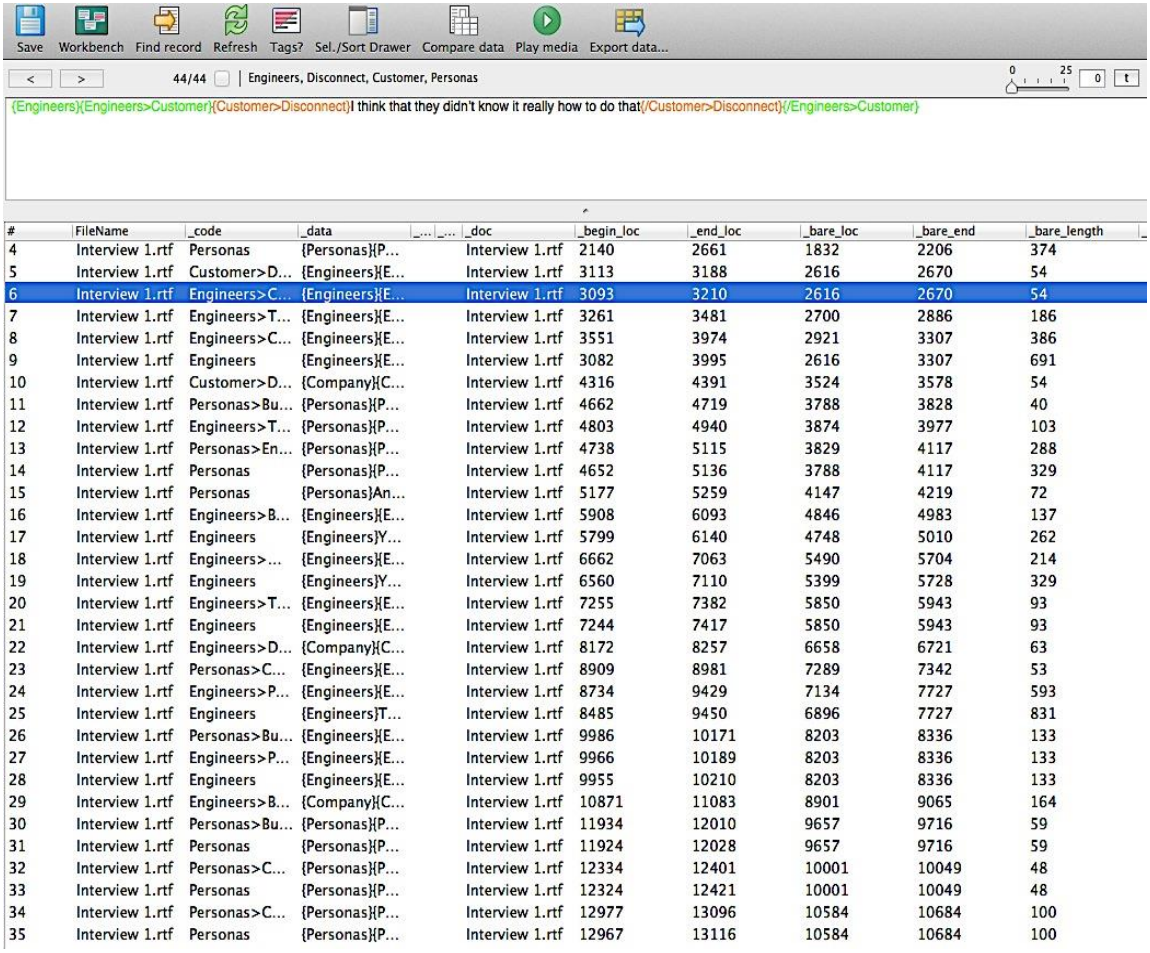


12.5 Appendix E – Example transcript coding



12.6 Appendix F – Example analysis of codes and relationships

12.6.1 Initial analyses of the coded quotes in TAMS Analyzer



#	FileName	_code	_data	_...	_...	_doc	_begin_loc	_end_loc	_bare_loc	_bare_end	_bare_length
4	Interview 1.rtf	Personas	{Personas}{P...			Interview 1.rtf	2140	2661	1832	2206	374
5	Interview 1.rtf	Customer>D...	{Engineers}{E...			Interview 1.rtf	3113	3188	2616	2670	54
6	Interview 1.rtf	Engineers>C...	{Engineers}{E...			Interview 1.rtf	3093	3210	2616	2670	54
7	Interview 1.rtf	Engineers>T...	{Engineers}{E...			Interview 1.rtf	3261	3481	2700	2886	186
8	Interview 1.rtf	Engineers>C...	{Engineers}{E...			Interview 1.rtf	3551	3974	2921	3307	386
9	Interview 1.rtf	Engineers	{Engineers}{E...			Interview 1.rtf	3082	3995	2616	3307	691
10	Interview 1.rtf	Customer>D...	{Company}{C...			Interview 1.rtf	4316	4391	3524	3578	54
11	Interview 1.rtf	Personas>Bu...	{Personas}{P...			Interview 1.rtf	4662	4719	3788	3828	40
12	Interview 1.rtf	Engineers>T...	{Personas}{P...			Interview 1.rtf	4803	4940	3874	3977	103
13	Interview 1.rtf	Personas>En...	{Personas}{P...			Interview 1.rtf	4738	5115	3829	4117	288
14	Interview 1.rtf	Personas	{Personas}{P...			Interview 1.rtf	4652	5136	3788	4117	329
15	Interview 1.rtf	Personas	{Personas}An...			Interview 1.rtf	5177	5259	4147	4219	72
16	Interview 1.rtf	Engineers>B...	{Engineers}{E...			Interview 1.rtf	5908	6093	4846	4983	137
17	Interview 1.rtf	Engineers	{Engineers}Y...			Interview 1.rtf	5799	6140	4748	5010	262
18	Interview 1.rtf	Engineers>...	{Engineers}{E...			Interview 1.rtf	6662	7063	5490	5704	214
19	Interview 1.rtf	Engineers	{Engineers}Y...			Interview 1.rtf	6560	7110	5399	5728	329
20	Interview 1.rtf	Engineers>T...	{Engineers}{E...			Interview 1.rtf	7255	7382	5850	5943	93
21	Interview 1.rtf	Engineers	{Engineers}{E...			Interview 1.rtf	7244	7417	5850	5943	93
22	Interview 1.rtf	Engineers>D...	{Company}{C...			Interview 1.rtf	8172	8257	6658	6721	63
23	Interview 1.rtf	Personas>C...	{Engineers}{E...			Interview 1.rtf	8909	8981	7289	7342	53
24	Interview 1.rtf	Engineers>P...	{Engineers}{E...			Interview 1.rtf	8734	9429	7134	7727	593
25	Interview 1.rtf	Engineers	{Engineers}T...			Interview 1.rtf	8485	9450	6896	7727	831
26	Interview 1.rtf	Personas>Bu...	{Engineers}{E...			Interview 1.rtf	9986	10171	8203	8336	133
27	Interview 1.rtf	Engineers>P...	{Engineers}{E...			Interview 1.rtf	9966	10189	8203	8336	133
28	Interview 1.rtf	Engineers	{Engineers}{E...			Interview 1.rtf	9955	10210	8203	8336	133
29	Interview 1.rtf	Engineers>B...	{Company}{C...			Interview 1.rtf	10871	11083	8901	9065	164
30	Interview 1.rtf	Personas>Bu...	{Personas}{P...			Interview 1.rtf	11934	12010	9657	9716	59
31	Interview 1.rtf	Personas	{Personas}{P...			Interview 1.rtf	11924	12028	9657	9716	59
32	Interview 1.rtf	Personas>C...	{Personas}{P...			Interview 1.rtf	12334	12401	10001	10049	48
33	Interview 1.rtf	Personas	{Personas}{P...			Interview 1.rtf	12324	12421	10001	10049	48
34	Interview 1.rtf	Personas>C...	{Personas}{P...			Interview 1.rtf	12977	13096	10584	10684	100
35	Interview 1.rtf	Personas	{Personas}{P...			Interview 1.rtf	12967	13116	10584	10684	100

12.6.2 Defining the themes in Excel

Category	Code	Qualitative Interviews Count	Reflective Journal
Barriers	Institutionalisation	19	
	Financial	4	
	Time	6	
	Workload	3	
	Customer awareness	19	
	Designer-Engineer disconnect	18	
Process	Status quo	12	
	Implementation	17	
	Responsibility	7	
	Timeframe	9	
	Acceptance	15	
	Needs	15	
Strategy	Customer insight	13	
	Design	2	
	Engineering	5	
Outcomes	Value	12	
	Quality	1	
	Personas	8	
	Tangible	4	
	Understanding	15	

Theme	Description
Institutionalised behaviour and thinking contributing to company inertia	The impact of a company-wide culture restricted by traditional, hierarchical methods. Furthermore, the effects on the design and development process
Design and development decision making concentrated amongst management	The influence of management in the decision making process due to the concentration of authority within firm management
Engineering design and development driven by technical requirements and disconnected engineers	The challenges in establishing a user centred engineering approach to vehicle development in a traditionally technologically driven environment. Furthermore, finding added value opportunities for UCD from an engineers' perspective.

12.7 Appendix G – Example of ethical consent form

Queensland University of Technology
Brisbane Australia

PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT
– Interview –

Technical product development in the automotive industry through the adoption of design led persona tools

QUT Ethics Approval Number

RESEARCH TEAM

Principal Researcher: Scott Bryant, Master student, QUT.
Associate Researcher:

DESCRIPTION

This project is being undertaken as part of a masters research project for Scott Bryant.

The purpose of this project is to assess the viability of personas (a customer modelling strategy) as part of a design led innovation (customer orientated/centred) strategy here at [redacted], and how the process of persona creation is adopted (or not) by [redacted] engineering staff, as part of the development of [redacted] vehicle design.

You are invited to participate in this project because you have influence over the decision making process (i.e. the vehicle design process) in your respective engineering/technical department, and would likely be responsible for the implementation of personas and user-centred technical-design if it was to be implemented in the future at [redacted].

PARTICIPATION

Your participation will involve an interview at the [redacted] research and development centre [redacted] that will take approximately 1 hour of your time. Questions will focus on such areas as:

- How is new product development approached in the company? How are new products introduced to the departments and processes?
- To what level do the design/operational departments communicate with one another and are aware of another's roles?
- I see a lot of resistance/negativity from engineers (in general) surrounding customer-driven design and designers/marketers approach to (vehicle) design; from your perspective, why do you think this is so?

Your participation in this project is entirely voluntary. If you do agree to participate you can withdraw from the project without comment or penalty. [If you withdraw, on request any identifiable information already obtained from you will be destroyed.] Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT.

EXPECTED BENEFITS

It is expected that this project will benefit you directly. Additionally, it is believed this project will allow the most effective approach to introducing personas and user-centred design in future [redacted] engineering projects.

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses will be treated confidentially unless required by law.

CONSENT TO PARTICIPATE

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

Scott Bryant – Master Student
Science and Engineering Faculty
+49 1577 537 0301
scott.bryant@student.qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on [+61 7] 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

Queensland University of Technology
Brisbane Australia

CONSENT FORM FOR QUT RESEARCH PROJECT
– Interview –

Technical product development in the automotive industry through the adoption of design led persona tools

QUT Ethics Approval Number

RESEARCH TEAM CONTACTS

Scott Bryant – Master Student
Science and Engineering Faculty
+49 1577 537 0301
scott.bryant@student.qut.edu.au

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.
- Have had any questions answered to your satisfaction.
- Understand that if you have any additional questions you can contact the research team.
- Understand that you are free to withdraw at any time, without comment or penalty.
- Understand that you can contact the Research Ethics Unit on [+61 7] 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project.
- Agree to participate in the project.

Name .....

Signature .....

Date .....

Please return this sheet to the investigator.